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A BRIEF

ON THE

OCTRINE OF THE CONSERVATION OF FORCES.

BY

THOMAS H. MUSICK,

OF THE

MISSOURI BAR.

PUBLISHED BY THE AUTHOR.

MEXICO, MISSOURI:
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PREFACE.

Prof. Faraday calls the doctrine of the Conservation of Energy "The highest law in physical science which our faculties permit us to perceive." Prof. Steele speaks of it as "The grandest law nature offers for the contemplation of the human mind." Dr. Youmans sketches "'the stupendous reach of the law," in the following eloquent words: "It might well have been proclaimed the highest law of *all* science—the most far-reaching principle that adventuring reason has discovered in the universe. Its stupendous reach expands all orders of existence. Not only does it govern the movements of the heavenly bodies, but it presides over the genesis of the constellations; not only does it control those radiant floods of power which fill the eternal spaces, bathing, warming, illumining, and vivifying our planet, but it rules the actions and relations of men, and regulates the march of terrestrial affairs. Nor is its dominion limited to physical phenomena; it prevails equally in the world of mind, controlling all the processes of thought and feeling. The star-suns of the remoter galaxies dart their radiations across the universe; and although the distances are so profound that hundreds of centuries may have been required to traverse them, the impulses of force enter the eye, and impressing an atomic change upon the nerve, gives origin to the sense of sight. Star and nerve tissue are parts of the same system—stellar and nervous forces are co related. Nay, more: sensation awakens thought and kindles emotion, so that this wondrous dynamic chain binds into living unity the realms of matter and mind through measureless amplitudes of space and time."

And these learned men do not over estimate the profound importance of the doctrine; for it not only underlies, modifies and determines the scope and value of all science, both physical and metaphysical, but of all religions as well. If, therefore, it is true, it is one of the grandest and most vital of all truths; if in any respect erroneous, it is, so far, the most dangerous of all errors.

From the moment of its promulgation by Mayer and Grove, it has been treated with a partiality and tenderness accorded to no other scientific theory of modern times. Instead of hesitating, doubting, scruti nizing and investigating, scientists seem to have been captivated, if not blinded, by the magnitude and grandeur of the thought, and to have joined in a race, not of testing, weighing and reasoning, but of piling up argument to support and demonstrate the hypothesis; so that, almost from the very beginning of the discussion, it has settled down in the scientific, as well as in the popular mind, upon a basis quite as fixed and solid as the doctrine of Gravitation itself.

It may, therefore, seem presumptious in any one, at this late day, to criticise, doubt or question its received principles. My apology for doing so, however, is to be found in a saying of Galileo's: "In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual."

The aim of this little pamphlet is not to trace out and define the boundaries of the doctrine, but to demonstrate that it is but of partial and limited application, neither broad enough, nor well enough established, to form a safe basis for any philosophical system.

If the doctrine is true in all its length and breadth, as taught, it will bear investigation, and its supporters can afford to be patient with criticism; but if, as is here contended, it is only limitedly so, then every interest of humanity demands the most searching discussion of the whole subject.

MEXICO, MO., August 14, 1878.

BRIEF.

The doctrine of the Conservation of Forces includes the following propositions:

1. *No old force is ever lost.*
2. *No new force is ever generated.*
3. *The quantum of all the forces in the universe remain constant.* S
4. *The different forms of force severally metamorphose into each other.*

Prof Helmholtz says: "We arrive at the conlusion that nature, as a whole, possesses a store of force which cannot in any way be increased or diminished, and that, therefore, the quantity of force in nature is just as eternal and unalterable as the quantity of matter. Expressed in this form, I have named the general law 'The Principal of the Conservation of Force.'"—*Interaction of Natural Forces—Tyndall's Translation* al

Prof Grove says: "Now the view which I venture to submit is that force cannot be annihilated, but is merely sub divided or altered in direction or character."—*Correltation of Physical Forces, page 27.*

Force is that which produces or tends to produce, or resists or tends to resist motion or pressure in matter.

Prof. Grove defines it as "that which produces or resists motion" (Page 19.)

But many writers seem to use force interchangeably with motion, and other terms. Thus we are sometimes told that heat is a force, and sometimes a mode of motion. Prof. Steele says: "What is the nature of force, we cannot tell. We think it to be a mode of motion."

In January No., 1878, of *Popular Science Monthly*, in an article on the "Logic of Sciences," Prof. C. S. Pierce says: Whether we ought to say that a force *is* an acceleration, or that it *causes* an acceleration, is a mere question of propriety of language, which has no more to do with our real meaning, than the difference between the French idiom, '*Il fait froid*,' and its English equivalent, 'It is cold.' Yet it is surprising to see how this simple affair has muddled men's minds."

Now the fact is, that the term force never does, and never can mean "an acceleration;" whilst often, though not always, by any means, it may mean "the cause of an acceleration. It is the cause of motion, and when motion is accelerated, it is the cause of acceleration.

Inertia is that property of matter which makes it susceptible to the action of force.

The condition of matter uninfluenced by force is that of *rest.* Motion is initiated and carried forward by force, and ceases when force ceases to act. There can be no motion ~~when,~~ when there is no force acting. Motion is destroyed, not by the application, but by the withdrawal, of force. The received doctrine is that force initiates, changes, and destroys motion, but that it is *inertia* which continues motion; that *motion* equally with *rest* is the normal condition of matter. Inertia is thus made a property of matter, by virtue of which, uninfluenced by force, it rests or moves indifferently. Thus in Steele's "Fourteen Weeks in Natural Philosophy," page 25: "When we try to start a heavy wagon, it requires a great effort, because we have to overcome its inertia, which tends to keep it at rest. When the wagon is in motion it requires as great an exertion to stop it, since then we have again to overcome its inertia, which tends to keep it moving."

This notion of inertia is a necessary consequence of the definition of force which makes it the originator, but not the continuer of motion. By the universally accepted doctrine of force, it is shorn of one-half of its office and work, necessitating the imposition of the other half on some other agency. Hence it comes that that burden has been laid upon *inertia,* and the two agencies, *force* and *inertia* are yoked together, in scientific thought and expression, to do the proper work of force alone. And, not only will the truth of this proposition appear continually, as we progress with our argument; but it will be seen that the abuse of language complained of lies at the bottom of a vast amount of scientific error, including the doctrine which it is the business of these pages to controvert.

§ 1. *All motion is produced and continued by force immediately in the moving matter, and acting upon it.*

Force does not act at a distance, but only when it is immediately present. This principle is universally recognized in mechanics, and in the common experiences of practical life; and it is only in the realm of science that a contrary notion obtains.

§ 2. *Gravitation is a force in matter, driving, or tending to drive its different portions towards each other, with velocities inversely as the masses and squares of the distances.*

This grandest law known in the domain of physical science, is Sir Isaac Newton's great discovery, except that he locates the forces at the wrong end of the line. He says *draw,* instead of *drive.* He makes it an *attraction,* instead of a *propulsion.* But gravitation is not reconcilable with a drawing or pulling force, and *attraction* of *gravitation* is a misnomer. The error arises from supposing that a force resident in one body can act upon another and distant body, in disregard of the first law above. Newton, however, did not believe that a force can act at a distance, except through some agency. Thus, he believed that the sun attracts the earth to him, through the use or agency of some intervening ethereal, or other medium.

Laplace seems to have entertained a similar view. And, indeed, when the mind grasps the subject with logical distinctness and precision, it is impossible to think that a force wholly resident in the sun can draw the earth to him. To enable the mind to form a clear and definite notion of any such action, the force, whatever it is, must be conceived to, in some way, take hold, as it were, of the earth, and act immediately upon it. That is, whenever the mind gets a precise notion of the motion of any mass of matter, it necessarily thinks the moving force present in the moving body, and acting upon it, and not elsewhere. The error comes, therefore, from indistinctness of thought; and it well illustrates Dr. Whewell's doctrine: that the great source of error in scientific progress, is obscurity of thought.

Much of the fault lies in the misuse of the word *attraction*. When a man is attracted to make a long journey, for the sake of the gold he expects to receive, the power of energy is in him, and only a directive or r determining of such power or energy in the precious metal. The gold does nothing, can do nothing; its concept in the mind determines the action of the man; and this is all that is meant by *attraction*, in this instance. But in physics, it can properly have no wider meaning. In the magnet, it should mean a directive quality, determining the action of forces in surrounding objecs. In the earth, it should mean a quality determining the action of forces resident in surrounding matter, as the moon, and terrestrial objects. It never should mean, a force or energy going out from the body towards which the motion exists, drawing the moving objects to it.

ILLUSTRATIONS.—1. Hail-stones fall by the force of gravity; the school boy whose head is pelted by them, and the farmer whose crops are beaten to the ground, alike recognize *that* force as being in the falling ice-stones themselves, and not in the earth beneath. And this is the universal logic and language of common experience. In practical life and thought, no man ever locates the force of a falling body anywhere else than in the body itself. It is only the scientific thought of the scientific mind which can accept such a logical invertion.

2 Force may be drawn off from falling bodies, and communicated to other bodies, producing motion in them. When a stone falls into a pool of water, not only is the whole pool thrown into undulations and waves, but the water is thrown up in drops and jets, from all around the point of impact.

3. Falling water communicates force to the factory wheel, and through it to spindle, shuttle and forge. Would any one say that the force in this instance comes out of the earth, instead of out of the falling bodies?

The proper definition and location of gravitation as a driving, instead of a pulling force, necessitates the change in the expression of the law governing it, so far as dependent upon mass, from a direct proportion as given by Newton, to an inverse proportion.

The law, so far as it is dependent upon distance, that is, that *gravitation is inversely as the sqares of the distances*, stands in direct contradiction to the proposition in the doctrine of the conservation of forces, that no new force is ever originated, in whatever light gravitation may be viewed, whether as a pulling or a driving, a constant or a constantly received force. For, earth's gravitation towards the sun, increases from aphelion to perihelion, and decreases from perihelion to aphelion, according to the law, and the force with which a comet is held to the sun at the distance of Mercury, is 5,818 times as great as at the distance of Neptune. Now whence comes this increased amount of force, and what becomes of it? The doctrine has not and cannot account for it.

Prof. Faraday recognized the contradiction; nevertheless, masterly in thought as he always was, and careful in investigation as he usually was, he preferred the illogical and unphilosophical recourse of supposing some unknown laws and properties of gravitation, which will, when discovered, explain the contradiction, to admitting a doubt of the Conservation theory.

§ 3. *The gravity with which a body falls towards the earth is a continuously received force, equal increments in equal times.*

This is proven by the law of falling bodies, that *distances fallen, will be as the squares of the times.*

Whenever it is admitted, that motion is produced by a force immediately present in a moving body, the conclusion follows, that any change of such motion, is a consequence of a corresponding change in the force producing it. An increase of motion means an increase of force; and where the increase of motion is uniform, as is that of falling bodies by the rule referred to, so must the increase of the causing force be uniform. At the end of the first second, there is a force, in a falling body equal to the production of 32 feet of motion in one second, and were there no increase of force it would fall at this rate through any length of time. But in the second second, it receives the same amount of force as in the first, and an equal amount in every succeeding second, with a corresponding uniform acceleration of motion.

§ 4. *A body at rest receives Gravity continually, equal increments in equal times.*

§ 5. *Gravity is constantly transmitted from all bodies at rest, in the form of weight or pressure.*

These laws mutually presuppose and depend upon each other.

Illustrations.—1. Four one-pound weights, resting upon each other, will weigh four pounds. This could not be the case, did not the upper weight constantly transmit the pressure of one pound, through the middle two, to the lower one, and through that to the scale beam. But if constantly transmitted, it must be in like manner received.

2. I put a twenty pound weight in one pair of a grocer's scales, and balance it by the pressure of my hand at the other end of the beam; this I do for a length of time until my arm becomes fatigued and exhausted. I then balance the scale with a bar of iron, instead of my hand. Now, it is clear that gravity in the iron, fills the same office as did the muscular energy of my hand for which it is substituted. The hand transmitted energy as is shown by its exhaustion; the iron must do the same, else it would not fill the place; but if it transmits force, it must receive it, else it would lose its weight, and cease to press downwards.

3. When a weight becomes too great for its supports, as a house for its pillars, the supports are crushed and the weight falls instantaneously.

4. The pressure of the weights of a clock runs all the machinery. The force of gravity in the weights, is transmitted by means of cords continuously to the wheels, else they would cease to move; but this transmission must be continuously supplied, else they would lose their weight, and cease to have force to impart.

5. The two propositions extend and apply to *all terrestrial matter.* It is all continuously receiving force in the Form of Gravity, and all that is at rest, by which I mean, supported, so as not to be falling towards the center of the earth, is as constantly transmitting Force in the form of weight or pressure.

6. One term of the doctrine of the Conservation of Energy is here continuously contradicted, for one form of force, at least, Gravity, is continuously generated.

7. So must one of the other terms be, in like manner, constantly contradicted, for, either there must be a vast amount of force continuously lost, or else the sum total of force in the earth must be constantly augmented by the *quantum* of continuously received gravity.

§ 6. *In all bodies at rest gravity is constantly received and transmitted in equal quantities.*

Were this not true, the weights of bodies would vary, becoming would greater or less as the amount of gravity received ~~shall~~ be greater or less than that transmitted.

§ 7. *Force is measurable by the product of the mass of the moving body into velocity.*

This is the law of the text books, and is stated repeatedly by Dr Balfour Stewart, *Elementary Physics, pages 14, 27, 48.* But Dr. Mayer takes the product of the mass into the square of the velocity as the measure of force. We shall hereafter see that Dr- Stewart and the text books are right.

Since the days of Galileo momentum has been measured by the product of mass into velocity. Therefore the measure of moving force and momentum are the same, or in other words momentum measures force.

But, while Dr. Stewart holds that force and momentum are proportional to the product of the mass into the velocity, he at the same time claims, that there is another factor, which he calls Energy, or "Capacity for Doing Work," and which is proportioned to the square of the velocity. And Prof. Tyndall says: "The measure then of mechanical effect, is the mass of the body multiplied by its velocity;" calling that "Mechanical Effect," which Dr. Stewart calls "Capacity for Doing Work."

Now, what is this factor which is neither force, motion, velocity, nor momentum, but which varies as the square of any one of these? for, mass remaining constant, when we double the force we double these other terms, but quadruple this factor, called Energy, or Mechanical Effect.

Suppose a ball of mass 1, acted upon by a force 1, it will move with a velocity 1, and a momentum 1. Now let it impinge upon another ball of like mass, and it will impart the same motion, velocity and momentum. Here the mechanical effect, or work done, is the moving of the second ball, that is, the impartation of a moving force to it. But let the force acting upon the first ball be doubled, then the motion, velocity, and momentum of that ball will be doubled; but the mechanical effect, or work exerted on the other ball will be quadrupled, that is, the second ball will move with a four-fold velocity and momentum, and if it strikes another ball of like mass, the latter will be driven forward with a velocity and momentum of 16, and the fourth ball struck would move with the velocity of 256, and so on.

But as force is measured by the product of mass into velocity the value of the force acting upon the first ball is 1 multiplied into 2, equal 2; on the second 1 multiplied into square of 2, equal 4; on the third 1 multiplied into the square of 4, equal 16; and on the fourth 1 multiplied into the square of 16, equal 256. That is, if the law is correct, simply causing bodies to impinge upon each other successively, multiplies force with extreme rapidity.

Now it is true that Dr. Stewart does not call this multiplied effect force, but *energy*, yet it is also true, nevertheless, that it fills the office of force, in producing motion in matter, and therefore, fills our definition of force.

Again, if Dr. Stewart and Prof. Tyndall are correct in this proposition, a horse running at the rate of twenty miles per hour should be able to carry a load twenty-five times as great as when walking at the rate of only four miles per hour, and we should be able to create power at will.

Dr. Stewart offers the following arguments in support of the proposition :

1. A rifle ball does greater execution than the recoil of the gun. But this only shows that the penetrating power, which may be a very different thing from the mechanical effect, is greater. A ball with rapid motion will penetrate the deeper, but when moving less swiftly it will tear and rend the more. Did the stock terminate in a point no broader than the ball, the difference would not be so great. If it terminated in a keen knife blade, perhaps it would be about as dangerous to stand at one end of the rifle as at the other. In the next place, the velocity of the ball being great, there is no time for its momentum to be communicated to the whole object struck, and it is spent in penetrating it, whilst, with the heavier stock, the velocity being small, there is time for the force to be communicated to the whole body, and the effect is a jar.

2. He thus states another argument in support of his position : A kilogramme shot upwards with the velocity of 9.8 metres in one second will be brought to rest when it has risen 4.9 metres in height. "We are, therefore, entitled to say that a kilogramme, shot upwards with the velocity of 9.8 metres per second, has energy equal to 4.9 inasmuch as it can raise itself 4.9 metres in height.

"Let us next suppose that the velocity with which the kilogromme is shot upwards is that of 19.6 metres per second. It is known to all who have studied dynamics that the kilogramme will now mount not only twice, but four times as high as it did in the last instance—in other words it will now mount 19.6 metres in height.

"Evidently, then, in accordance with our principles of measurement, the kilogramme has now four times as much energy as it had in the last instance, because it can raise itself four times as high, and therefore do four times as much work, and thus we see that the energy is increased four times by doubling the velocity.

"Had the initial velocity been three times that of the first instance, or 29.4 metres per second, it might in like manner be shown that the height attained would have been 44.1 metres, so that by tripling the velocity the energy is increased nine times."—*Conservation of Energy, page 18.*

But the facts given are a necessary deduction from the continual increment of gravitating force. The kilogramme when shot up with the velocity of 9.8 metres per second, will only rise to the height of 4.9 metres, because it is all the time retarded by successive increments of gravity, in quantity sufficient to carry it from a state of rest, to 9.8, in the same time; so that its average velocity upward, is the mean between 0 and 9.8 metres, to-wit: 4.9 metres, and to that height it will ascend during that second; ~~leaving at its end, a remaining velocity of 9.8, which will carry it 4.9 as in the former instance.~~ When shot up with three times the initial velocity, to-wit: 29.4 metres, the retardation in in the first second will be the same as before, 9.8 metres, the average velocity for that second the mean between 19.6 metres and 29.4 metres, to-wit: 24.5 metres, and consequently, the ascent the same, 24.5 metres; with a remaining velocity of 19.6 metres. In the second second, the retardation is the same, 9.8, the average velocity 14.7, the ascent 14.7, and the remaining, velocity 9.8 metres. In the third second the retardation will be 9 8, the average velocity 4.9, the ascent 4.9, and the remaining velocity 0. Now the sum of 24.5, 14.7, and 4.9 metres equals the product of 4.9 metres multiplied by 9.

Prof. Tyndall uses the same illustration: " Now the work done,—or, as it is sometimes called, the mechanical effect,—as before explained, is proportional to the height, and as a double velocity gives four times the height, and so on, it is perfectly plain, that the mechanical effect increases as the square of the velocity."—*Annual of Scientific Discovery, 1865, page 104.*

It seems very strange that these great thinkers should not have perceived the true cause and principle of the retardation of ascending bodies; that they should not have noticed that it is strictly the result of meeting and overcoming equal amounts of resistance in successive seconds of time; and that it should have escaped their attention that the amount of such resistance overcome is strictly in proportion to the velocities; that when the upward velocity is 32 feet, the resistance overcome is one second of gravity; that when the velocity is 64 feet, 2 seconds of gravity is overcome; and that when the velocity is 96 feet, 3 seconds of gravity is met and balanced.

It is readily to be seen, however, that the error has arisen by their taking the height ascended as the whole measure of the work done. The resistance of gravity is the same in each successive second whether the upward velocity be great or small, and the upward motion will continue until the projectile force is exhausted by such resistance. But they have wholly overlooked this resistance.

The same error is repeated in getting a unit of measure for work. Thus Prof. Tyndall says: "The absolute amount of work done depends solely upon two things: first of all, on the quantity of matter that is lifted; and, secondly, on the height to which it is lifted. Page 103.

And in Elementary Physics, page 101, Dr. Stewart says:

"If a kilogramme be raised one metre high against the force of gravity, we may call it one unit of work, in which two kilogrammes raised one metre high, or one kilogramme raised two metres high, will represent two units, and so on. We have, therefore, only to multiply the number of kilogrammes by the vertical height in metres to which they are raised, and the product will represent the work done against gravity."

Now, it is very evident, that an important element, to-wit, time, is left out. There is twice as much labor in holding two pounds in the hand as one pound, for the same length of time; but there is a half more work in holding one pound three seconds, than in holding two pounds one second; so that the time of the ascent must be considered, because the gravity to be overcome is as the time. The laws for the measurement of work done are obtainable on these principles.

I shall take for the measure of gravity:

§ 8. *The velocity attained by a body falling one second, to wit: 32 1-6 feet or 9-8 metres.*

The work done, that is the pressure exerted by a body at rest is one problem while that done by moving bodies involves four different problems.

The first case is statical—work done by a body at rest. Here there is no translation through space, but simply pressure or weight. We have nothing to do with motion but only with gravity And as equal increments of gravity are received and passed off in the form of pressure in equal times, our rule is:

§ 9. *Take the product of mass into gravity and that into time.*

Thus if mass be 10 lbs. and time 4 seconds, we have for work done, omitting fractions: the several product of 10, 32 and 4, equal 1280 lbs. for work done.

The first case in motion is that of a falling body. Here leaving out of view atmospheric interference, as I shall all the time do, we have nothing but translation, unresisted motion, to deal with. We may take for our rule, therefore:

§ 10. *The product of mass into distance fallen:*

Or what gives the same result:

The product of mass into one half of gravity, and that into the square of time.

Thus with the same terms as before, we find the distance by the law of falling bodies to be 255 feet, and, we have the product of 10 into 256 equals 2560 lbs. for work done.

The third case is that of horizontal motion, and is more complicated, for we have to consider other forces, and have both translation and gravity as elements of calculation. Taking the element of translation or motion first, it is found by taking the product of mass velocity and time; that is of momentum into time. The element of gravity in this problem may be explained by supposing a round ball of the same mass, rolling over a floor of ice with the same velocity and for the same time. It is evident that its pressure upon the floor while rolling over it, would be precisely the same, as if it were at rest for the same time, and of course must be found in the same way; or, if we suppose the ball unsupported, it will fall just as far in the time as if dropped perpendicularly. We have the rule, therefore:

§ 11. *Take the product of mass into velocity and that into time, and to this add the product of mass into gravity, and that into time.*

Thus if we have mass and time as before and velocity 50 per second, then we have the several product of 10, 50 and 4 added to the several product of 10, 32 and 4, equal 3280 lbs. for work done.

The next case is that of a body moving upwards, (under a uniformly applied force as of steam or muscle) and it is still more intricate for we have not only translation but gravity in a double aspect, in this that the upward force, not only has to resist the statical measure of gravity which the body at rest or the rolling ball transmits downwards, but it has to mount in resistance to an additional equal measure of gravity The upward motion has to overcome not only the measure of work which it would do if at rest, but to neutralize an equivalent amount of gravity as well.

But this thing is to be observed: if the upward velocity is less than gravity, the resistance to the upward flight is not the full amount of gravity but only gravity equal to the velocity; this causes a subdivision of the case and gives us two rules under it. In the first velocity is greater than gravity.

§ 12. *Take the product of mass into velocity and that into time, and to this, add twice the product of mass into gravity and this into time.*

Thus taking the same terms we have: the several product of 10, 50 (and) 4 added to the several product of 2, 10, 32 and 4 equals 4560 lbs. for work done.

When velocity is less than gravity the rule will be:

§ 13. *Take twice the product of mass into velocity and that into time, and to this, add the product of mass into gravity and this into time.*

Thus taking velocity at 20 and the other terms as before we have the several product of 2, 10, 20, and 4 added to the several product of 10, 32, and 4 equals 2,880 lbs. for work done.

The fifth problem is that of a body projected upward. The principle is the same as in the last except that here velocity is uniformly retarded, and our rule is:

§ 14. *Take the product of mass into average velocity and that into time, and to this, add twice the product of mass into gravity and that into time.*

But as the terms usually given are only mass and initial velocity, time and average velocity are to be found. Dividing initial velocity by gravity gives time of ascent, and average velocity is the mean between initial velocity and final velocity or 0.

Thus if mass be 10 and initial velocity 128, time will be 4, average velocity 64, and we shall have the several product of 10, 64 and 4 added to the several product of 2, 10, 32 and 4 equals 5,120 lbs. for work done.

§ 15. *The momentum of a body after having fallen any given number of seconds will just equal the pressure which the same body will transmit in the same length of time, if at rest.*

This is consequent upon §§ 3 and 4.

Of course reference is had to the pressure of solids, and no allowance is made for the resistance of the atmosphere to the fall.

Dr. Stewart, in Consirvation of Energy, page 23, takes a different view of this law. He says: "And now let us state that this same energy or power of doing work may nevertheless be possessed by a body absolutely at rest. It will be remembered (Art. 26) that in one case where a kilogramme was shot vertically upwards, we supposed it to be caught at the summit of its flight, and lodged on the the top of a house. Here, then, it rests without motion, but yet not without the power of doing work, and hence not without energy. For we know very well that if we let it fall it will strike the ground with as much velocity, and, therefore, with as much energy, as it had when it was originally projected upwards. Or we may, if we choose, make use of its energy to assist us in driving in a pile, or utilize it in a multitude of ways.

"In its lofty position it is, therefore, not without energy, but this is of a quiet nature, and not due in the least to motion. To what, then, is it due? We reply, to the position which the kilogramme occupies at the top of the house. For just as a body in motion is a very different thing (as regards energy) from a body at rest, so is a body at the top of a house a different thing from a body at the bottom."

Again, on page 27, he says: "We have thus endeavored to show that there is an energy of repose as well as a living energy, an energy of position as well as of motion; and now let us trace the changes which take place in a weight, shot vertically upwards, as it continues to rise. It starts with a certain amount of energy of motion, but as it ascends, this is by degrees changed into that of position, until when it gets to the top of its flight, its energy is entirely due to position.

"Take an example, let us suppose that a kilogramme is projected vertically upwards with the velocity of 19.6 metres in one second. According to the formula of Art. 28, it contains 19.6 units of energy due to its actual velocity.

"If we examine it at the end of one second, we shall find that it has risen 14.7 metres in height, and has now the velocity of 9.8. This velocity we know (Art. 26) denotes an amount of actual energy equal to 4.9, while the height reached corresponds to an energy of position equal to 14-6. The kilogramme has, therefore, at this moment a total energy of 19.6, of which 14.7 units are due to position, and 4.9 to actual motion.

"If we next examine it at the end of another second, we shall find that it has just been brought to rest, so that its energy of motion is *nil*; nevertheless, it has succeeded in raising itself 19.6 metres in height, so that its energy of position is 19.6.

"There is therefore, no disappearance of energy during the rise of the kilogramme, but merely a gradual change from one kind to another. It starts with actual energy, and this is gradually changed into that of position, but if at any stage of its ascent, we add together the actual energy, and that due to position, we shall find that this sum always remains the same.

"Precisely the reverse takes place when the kilogramme begins its descent. It starts on its downward journey with no energy of motion whatever, but with a certain amount of energy of position; as it falls, its energy of position becomes less, and its actual energy greater, the sum of the two remaining constant throughout, until, when it is about to strike the ground, its energy of position has been entirely changed into that of actual motion, and it now approaches the ground with the velocity and, therefore, with the energy, which it had when it was originally projected upwards."

1. Now, all the time that the body is ascending in this instance, it is receiving gravity which is utilized in overcoming the projectile force; and, at the moment when the two forces have exactly balanced each other, the body is brought to rest, but gravity continuing to act, it immediately starts on its descent, and falls with the accelerated velocity produced by continuous increments of force, until the ground is reached, when the whole amount of accumulated force is communicated thereto by percussion. At three points, immediately before the body started up, at the highest point of ascent, and after reaching the ground, it is in the same condition as regards the presence of force; for in each instance, it is without force, except that of gravitation instantaneously

received. During the ascent, it has the continuously retarded projectile force, and during the descent, the continuously received gravitating force.

2. Now suppose two stones simultaneously projected upwards with the same velocity, the one turning in mid air, and the other lodged at the same height on the edge of a roof. The projectile force is overcome in each alike by gravity, and momentarily, they are alike destitute of force as though neither projection nor gravity had ever acted upon them. The one falls immediately, receiving and storing up gravity during all the time of the descent. But while it is falling, the other, resting on the roof edge, is all the time receiving an equal amount of gravity, which it is transmitting through the walls of the house to the ground beneath; the only difference being that one retains and accumulates the force, while the other continuously transmits it. After the first stone has struck the ground, they are again in the same condition, receiving and transmitting the same amount of force, in like time and manner. And it matters not how long the latter stone may lie on the roof. If for one second, it will have transmitted a force that would have carried it downwards 16 feet in the time, if for one minute, it will have transmitted 60 times that amount of force.

3. I think that we are now prepared to understand that a body at rest cannot be possessed of energy, other than that of momentarily received and transmitted gravity. *Energy of position* can mean nothing more than a convenient situation for utilizing the force of gravity; just as the woodman, who, with axe in hand, has reached his tree, may be said to be in convenient position for his work. The paper-weight resting on the table, is in convenient position for its appropriate use, and, figuratively, I suppose, may be said to have *energy of position*. In the same sense the like may be said of the seige gun in position.

4. Dr. Stewart assigns to bodies at rest, latent, stored up energies of prior activities, which may at some future time be made to do work; I make them do work continuously in transmitting continuously received gravity in the form of pressure.

5 He seems to use the word here, not in the sense of force, nor of momentum, or power, nor yet of motion or velocity, but of *situation or position* simply, that is, a situation from which the force of gravity may act upon it in producing certain motions.

6. This indefinite and indeterminate use of the word *energy*, causes great confusion of thought and tends to wrap the subject in shadow. If *energy* means force; why not so use it? If it means momentum, or power, or motion, why pervert its use? If it means any of these it cannot mean a position of convenient use. If it means a force, it does not mean a stone, or other body. If it means motion, it does not mean rest. If it means momentum, it does not mean quiescence. If it means power it does not mean position.

7. The expression, *energy of position*, is a broken crutch brought to support the doctrine of the conservation of energy; for, it is very clear, that the projectile force with which the stone ascends, passes from view as force; and, unless it can be followed, and founed in some other form, there is a fatal break in the argument. But, as it cannot be traced in actuality, its place is supplied by nonenity. We are told that while force cannot be followed as force, nevertheless it can be traced in its an-

tithesis and negation, followed by the, "*therefore, no force is ever lost.*"

§ 16. *When any molar force acts against gravity they mutually overcome and neutralize each other.*

This follows as a necessary consequence of the preceding laws. The projectile force in the ascending stone is neutralized by gravity, while, at the same time, it neutralizes an equal amount of that force.

Dr. Stewart in the above quoted work, page 79, uses this illustration: "A pendulum, for instance, when at its lowest point, has only the energy of actual motion, in virtue of which it ascends a certain distance against the force of gravity. When, however, it has completed its ascent, its energy is then due to position, and not to actual motion; and so on it continues to oscillate, alternately changing the nature of its energy."

Prof. Grove says, page 31: "To wind up a clock, a certain amount of force is expended by the arm; this force is given back by the descent of the weight."

Prof. Liebig says, page 388: "The motion of a clock is produced by a weight or spring; but it is the power of the human arm applied to stretch the spring or elevate the weight, which is expended in the movement of the wheels and pendulum in twenty-four hours, or in eight or fourteen days."

Herbert Spencer, in First Principles, pages 184 and 185, illustrates something of the same view by the swinging of a chandelier. Says he: "If that element in the chandelier's motion of which alone we can allege continuity, is the correlation of the muscular effort which moved the chandelier, what becomes of this element at either extreme of the oscillation? Arrest the chandelier in the middle of its swing and it gives a blow to the hand—exhibits some principle of activity such as muscular effort can give. But touch it at either turning point, and it displays no such principle of activity. This has disappeared just as much as the translation through space has disappeared. How, then, can it be alleged that though the motion through space is not continuous, the principle of activity implied by the motion is continuous?

"Unquestionably the facts show that the principle of activity continues to exist under some form. When not perceptible it must be latent. How is it latent? A clue to the answer is gained on observing that though the chandelier when seized at the turning point of its swing, gives no impact in the direction of its late movement, it forthwith begins to pull in the opposite direction; and on observing, further, that its pull is great when the swing has been made extensive by a violent push. Hence the loss of visible activity at the highest point of the upward motion, is accompanied by the production of an invisible activity which generates the subsequent motion downwards.

I offer the following explanation of this phenomenon: When the chandelier is pushed upwards, the force imparted by the hand is continuously opposed by gravity, the two forces mutually neutralizing each other until the former is exhausted, when the chandelier stops, momentarily, as though neither force had acted upon it at all; but gravity continuing without cessation, it falls with accelerated velocity to the lowest point of the arc, by which time it has accummulated force sufficient to carry it against the now resisting gravity, to the highest point on the other side, that is, until the accumulated force of gravity is exhausted by the resistance of continuously received gravity; when it momentarily rests without motion and devoid of force, as at the former highest point of oscillation; but gravity still continuing to act, the same process is repeated in vibrations from side to side; in the descent, gravity being accumulated, and in the ascent, the accumulation mutually neutralizing and being neutralized by contemporaneously received gravity.

"The principle of activity," by which must be meant the force with which the chandelier moves, does not become latent, but is resisted, overcome, and neutralized by gravity. For, if the push which carries the chandelier up to the first highest point of oscillation, is there made latent, for a moment, to reappear immediately and carry it down to the lowest point and up to the other highest point, what is gravity doing during the process? Does it not pull against the upward push and pull with the downward pull, and against the upward swing again? If not, what neutralizes it? If so, what account does Mr. Spencer's theory take of it?

M. Arago says: "When the pendulum deviates from the vertical, the action of gravity brings it back."

The pull is greatest when the swing is greatest, because the chandelier, oscillating from a higher point, falls more directly downwards, and the action of gravity is thus more direct. On the same principle rests the fact that the oscillations will be made in the same time, whether through a greater or lesser arc.

In the illustrations taken from Profs Grove and Liebig, if it is the stored up muscular energy which runs the clock, what becomes of gravity? What does it do? It cannot be denied that it acts all the time, and directly on the weights, and that the weights all the time pull directly down on the cords, for they keep them tense, and if the latter be cut, the weights fall, and, as little can it be denied, that it is this pulling of the cords that keeps the wheels, pendulum, and hands moving. But if all this be so, how can it be said that the motion is produced by the stored up energy of the arm which wound the clock? Is it not very clear that such thing can be true, only figuratively, and not really at all?

In winding the clock the muscular energy of the arm is exerted against the gravity of the weights, the two forces neutralizing each other all the time of the process; after which gravity continues to act, a part of it being expended in driving the weights towards the earth, but a much larger portion in running the machinery and resisting the mechanical contrivances by which the motion is toned down and regulated.

Dr. Mayer distinguishes force into "two species," which he calls *motion* and *falling-force*. He says, page 343: "By 'falling force,' we understand a raised weight, or still more generally, a distance in space between two ponderable bodies." On page 345 he says: "Whenever a given quantity of falling-force disappears, motion is produced, and by the expenditure of this latter the falling-force can be reproduced in its original amount.

"This constant proportion which exists between falling-force and motion, and is known in the higher mechanics under the name of 'the principle of the conservation of *vis viva*,' may be shortly and fitly denoted by the term transformation.' For instance, we may say that a planet, in passing from its aphelion to its perihelion, transforms a par of its falling-force into motion, and, as it moves away from the sun again, changes part of its motion into falling-force."

Dr. Mayer's *falling-force* seems about equivalent to Dr. Stewart's *energy of position*, but it will be noticed that it is not force or motion or momentum that Dr. Stewart's system conserves, but *energy*, or the capacity of doing work. Dr. Stewart does not say, therefore, that the force by which the body is thrown upwards is conserved, but that the *energy*, or the power of doing work, subsists. In one aspect they are more, and in another less logical than Dr. Stewart. When it is shown that forces are neutralized and lost, Dr. Stewart can say yes; but my doctrine is not that forces, but energies, subsist. But they can reply, energies of what? Of forces? If so, how can a quality subsist when its subject is lost?

But let us return to Dr. Stewart's illustration of the projected stone. He sees, not the force in fact, but the *energy of projection* transformed into *energy of position*; into *rest* upon the house top. Now the first query is, what becomes of the projectile force itself? Its energy is subserved, but what becomes of its substantial self? The next question is, what becomes of either the force of gravity or the energy of such force during the time of the descent of the stone? Neither Dr. Stewart, nor any other writer that I have seen, takes any notice of it. The upward projectile force they try to save; but the equal downward-driving force of gravity they ignore.

In the third place, the tangible, definite existence of the projectile force is metamorphosed into an intangible place relationship—a real, active, essential existence, into feet and inches, this way and that way; essential reality into a non-essential non-entity.

In the fourth place, none of the theories make any disposition of the gravity continuously received by the stone after its lodgment. It may rest on the roof minutes, days, or centuries, and all that time it is continually receiving and transmitting gravity through the roof, walls, and foundation stones of the house, but no account is taken of it all

The fact is, that both Dr. Stewart and Dr. Mayer virtually beg the question and abandon the argument, when the one makes distance, and the other position, simple intangible space relationships, correlations of living, active forces. The startling proposition that Force, one of the two grand factors of the Universe, and Space, a simple intangible form or mode of existence, may pass interchangeably into each other, demands something more than a mere plausible theory to support it. It needs explanation of how it can be, as well as evidence that it is. Not only so, but when stripped of obscurity of expression and set forth in clear and precise terms, the mind at once recognizes its impossibility. For, according to Hamilton's doctrine of the conditioned, when we have once thought any force in existence we cannot think it out of existence, for that would be to think the nothingness into which it should pass. No more can we think it transformed into any modal form of existence, as space, for that is to think its essential, substantial attribute, its *essence*, out of existence, necessitating the thought of the zero into which it should vanish. The mind cannot think zero, because it cannot grasp it and cannot measure itself by nothing. But it is equally impossible to think of space metamorphosing into force, or into any other entity, or into time, or motion, or any other mode of being, for that matter. The mind is utterly incapable of formulating the notion of the transformation of space into any other existence, whether essential or modal. Space once thought is necessarily thought as space forever. It follows, therefore, that there is no solid or tangible basis for the theories of Dr. Stewart and Dr. Mayer, which have done such plausible work in supporting the Conservation doctrine, and without which it would necessarily have fallen of its own weight, long ago.

It is true that Dr Mayer offers mathematical formula in support of his proposition. Mathematics is an exact science, and its deliverances are not to be doubted whenever and wherever properly applicable to the subject under discussion. But the question in hand is not a mathematical problem at all. It is not a numerical question. It is not a problem of measurement or of quantity, but of transformation of existence. Therefore, any mathematical disquisition of the subject is out of place and fruitful of error.

Mr. Spencer's theory of invisible or latent activity is not as unthinkably illogical as the others, but is, nevertheless, not only without evidence for its support, but it leaves unexplained and unaccounted for the whole of the phenomena of gravitation.

I think, therefore, that I am entitled to claim that the conservationists have wholly failed to trace, or account for, the correlation to the forces which disappear when projectile or other forces act in opposition to gravity.

While, as will be seen by the foregoing extracts, the views of scientists vary as to the natures of force and energy, I suppose that the opinions of Vice President Thurston, contained in the address delivered at the late meeting of the American Association for the Advancement of Science, at St. Louis, may be taken not only as presenting the advanced notions on the subject, but as being scientifically orthodox.

Mr. Thurston says: "The grand principle which we are just beginning to admit and recognize as underlying every branch of knowledge, and as forming the foundation of all the sciences—of all sciences—seems, when stated, to be simply an axiom. The Scriptural declaration that the universe shall endure forever, is but a statement of the principle which is now becoming more and more generally admitted as a scientific truth, viz: That the two products of creation—matter and force and the fruit of their union—energy are indestructible.

"The grand basis of all science is found, then, in the principle: All that has been created by Infinite power—matter and its attribute force and all energy—is indestructible by finite power, and shall continue to exist as long as the hand of the Creator is withheld from their destruction. This law has been admitted almost from the time of Lavoiser, so far as it affects matter; it has been admitted as applicable to energy since the doctrine of correlation of forces and the persistence of energy became acknowledged by men of science, and we are gradually and rapidly progressing toward the scientific establishment of the law of persistence of all existence, whether of matter, force and energy or of organic vitality, and perhaps even of soul life. The truths of science are thus coming into evident accord with those doctrines of religious belief which underlie every creed. We are, however, apparently as far as ever from the determination of the question whether the higher forms of force and energy have quantivalent relations and intertransformability, notwithstanding the fact that a belief in the identity of mind and matter, and that in matter can be discovered 'the promise and potency of all terrestrial life,' has been avowed, explicitly or implicitly, by more than one great thinker, who has wandered into the realms of speculation.

"Looking back to the beginning, we see, then, that in the beginning there entered upon an existence which is of indefinite duration, a great universe of matter endowed with its characterizing attributes—the forces of nature. These forces acting upon all matter gave birth to a fixed amount of actual energy, and are capable of producing another fixed quantity of what is now potential energy. Energy thus coming into existence remains constant in amount as the quantity of created matter remains constant.

"The action of these forces upon this matter has given rise to every phenomenon which has come or does now come within the range of scientific inquiry."

Now upon analyzing this doctrine we shall find that it asserts the following propositions:

1. Force is an attribute of matter, and not an independent existence parallel with it.

2. This attribute acted upon its own substance—matter, in the production of ACTUAL ENERGY.

3. The quantity of actual energy thus produced was fixed—that is, limited.

4. This attribute, thus acting, is also capable of producing a fixed amount of *potential energy*.

5. These four, the substantial existence—matter, its inhering attribute—force, and the progeny of the union of substance and its attribute,—the two forms of *energy*, are indestructible by finite power.

Now in no proper sense of the term *attribute*, can it be an activity, can it act, do, or perform; that capacity belongs alone to the substance in which it inheres. And certainly without an abuse of language, it cannot be said that an attribute can act upon its own substance so as to educe therefrom a new form of existence. But passing all this, if force be an attribute of matter it cannot exist apart from its substance, it cannot be transferred to other substances, it cannot be transformed into other qualities. Therefore force is not susceptible to metamorphosis and one term of the Conservation doctrine is contradicted. But it has done one half, at least, of its work, did it, presumably, at the early dawn of creation,—it acted upon its own substance in the production of a *fixed* amount of *actual energy*, so that, on that line, there is nothing more for force to do; it has filled its offices and is no longer a factor to be considered in the problem of conservation. But on another line it is capable of producing a *fixed* amount of *potential energy*.

How much of this fixed quantity it has already produced and how much is left for future production, nor yet when it shall all have had "birth," we are not told.

Now what is it that acts upon matter in the production of motion. It would not seem to be force for its office is filled in generating energy. Yet we are told that, "the action of these forces on this matter has given rise to every phenomenon which has come or does now come within the range of scientific inquiry." But if force causes motion what is the office of actual energy?

Again, Dr. Stewart's positional energy seems to have been intended as convenient habiliment for the disguise of actual energy, where to the senses of man, it passes into nothingness. But Mr. Thurston does not so use the term, for he makes it equally with actual energy, a direct production of force and not a metamorphosis of actual energy. Fixed amounts of both are produced by force—how will Mr. Thurston bridge the chasm, over which Dr. Stewart has thrown positional energy?

And once more we may ask, what is energy? A something born of the union of force and matter ought to be tangible, susceptible of definite mental formulation, something with a place and a purpose in creation. Matter we know, force we know, motion we know, so of velocity and momentum and time and space. These can all be grasped in thought and defined in language. Can energy be? Yes when the word is left to its ordinary signification for then it is but an expansible synonym for force. But as used for a new factor in existence it has not been defined and is not susceptible of definition, because there is no room or place for any such new factor. Force, Matter, Motion,—these fill the measure and capabilities of physical nature and there are no crevices left into which may be driven wedges born of restless twilight nebulosity of thought.

§ 17. *Whenever gravity and any other force act against each other, at any angle whatever, they mutually neutralize each other, in equal amounts, and in proportions, varying with the angle of opposition, producing motion compounded of the former directions, according to the law of the parallelogram of forces.*

§ 18. *This is grandly illustrated in the economy of the orbital movements of the Solar System.*

But it gives us a very different theory of the Universe from that ordinarily set forth in the text books, although from the very indefinite character of the language used, it is often impossible to tell just what astronomical writers do intend to teach on the subject, and, indeed, it is presumable that usually they have no very distinct notions to express regarding it.

The two dynamic systems may be thus contrasted:

The one founded upon the above laws teaches:

1. That the motion of a planet in its orbit is caused wholly by gravitation.
2. That the gravitation producing such motion is not resident in the sun but is immediately present in, and acting upon the moving planet.
3. That such gravitation is a continuously received force equal quantities in equal times.
4. That the forward motion of the planet is produced by a continuous recomposition out of such constantly received gravitation and centrifugal force; that is, that the centrifugal or driving force of the present moment is compounded of the centrifugal force of the immediately preceding moment and the gravitation received during the same time according to the law of the parallelogram of forces.
5. The two forces continuously exhaust each other by opposition in equal quantities, according to the last named law.

The system of the books teaches:

1. That the forward motion is produced wholly by centrifugal im-

pulse or inertia

2. That such impulse was originally imparted to the planet by the power which formed it, and that it has ever since remained constant and unchangeable, under the form of Inertia.

3. That the planet is held in its orbit by gravitation.

4. That such gravitation is a constant and unchanging force resident in the sun.

5. That gravitation acts upon the planet by pulling it towards the sun continuously, thus changing the direction of its motion at every point.

6. That the orbital motion consists, therefore, of the continuous forward motion produced wholly by the original and continued centrifugal force or Inertia, and a continuous change of direction caused by the constant pulling of gravitation; that is, that the forward motion of the planet is, to-day but the precise continuing result of an original impulse, while the whole office of gravitation is fulfilled in deflecting the line of motion from a rectilinear into a curvilinear path.

It would be difficult, perhaps, to find this whole doctrine laid down in any single work, but taking the general treatment of the science of Dynamics with the exposition of its application to the Solar System by various authors, I think I am justified in the above statement of received opinions.

Thus, Dr. Whewell, in speaking of the Greek School of Dynamics, (*History of Inductive Sciences, Vol. 1. Page 313,*) remarks that, "they confounded the causes which *produce*, and those which *preserve*, motion." Again, on *Page 324*, he says: "The first Law of Motion asserts that the motion of a body, when left to itself, will not only be uniform, but rectilinear also." On *Page 320,* he says: "But the most common mistake of this period was, that of supposing that as a force is requisite to move a body, so a perpetual supply of force is requisite to keep it in motion. The whole of what Kepler called his 'physical' reasoning, depended upon this assumption. He endeavored to discover the forces by which the motions of the planets about the sun might be produced; but, in all cases, he considered the velocity of the planet produced by, and exhibiting the effect of, a force which acted in the direction of the motion. Kepler's essays, which are in this respect so feeble an unmeaning, d have sometimes been considered as disclosing some distant anticipation of Newlon's discovery of the existence and law of central forces. There is, however, in reality, no other connection between these speculations than that which arises from the use of the term *force* by the two writers in two utterly different meanings. Kepler's Forces were certain imaginary qualities which appeared in the actual motions which the body had; Newton's Forces were causes which appeared by the change of motion: Kepler's Forces urged the bodies forwards; Newton's deflected the bodies from such a progress. If Kepler's Forces were destroyed, the body would instantly stop; if Newton's were annihilated, the body would go on uniformly in a straight line. Kepler compares the action of his forces, to the way in which a body might be driven round, by being placed among the sails of a wind-mill; Newton's Forces would be represented by a rope pulling the body to the center. Newton's Force is merely mutual attraction; Kepler's is something quite different from this; for though he perpetually illustrates his views by the example of a magnet, he warnes us that the sun differs from a magnet in this respect that its force is not attractive but directive.''

Prof. Steele says: "*The motion of the heavenly bodies* presents the grandest illustration of the operation of these forces. The earth, when first formed, we may suppose, was hurled into space by the hand of the Creator with a force which would send it along the line *B* C in Fig. 31. According to the law of inertia it would never lose its force but would continue to move forever in a straight line. Being attracted, however, by the sun in the direction B S, it passes along the line *B* D, which is the resultant of these two forces. Should the earth ever lose its own motion, it would fall into the sun and feed that central fire. Should the attraction of the sun cease, it would fly off with headlong speed into the icy, cheerless regions of space. *Fourteen weeks in Natural Philosophy Page 76.*

J. Norman Lockyer, the distinguished astronomer, says: "As these laws were given to the world by Kepler, they simply represented facts, but Newton showed that they established the law of gravitation and flowed naturally from it. He proved that the motion of a planet in any part of its orbit is the result of two forces—one the original impulse, which gives it a tendency to move off from its orbit in a tangent and which is called *Centrifugal Force*—the other the *attraction of the Sun,* which deflects it towards that body, and is called *Centripetal Force.*''—*Elementary Astronomy, Page 280.*

And on Page 281, he says: Were the attraction of the central body to cease, the revolving body would leave its orbit, in consequence of the centrifugal tendency it acquired at its start; were the centrifugal tendency to cease, the centripetal force would be uncontrolled, and the body would fall upon the attracting mass.''

Prof. Newcomb says: "The great misapprehension which possessed the minds of nearly all mankind till the time of Galileo was, that the continuous action of some force was necessary to keep a moving body in motion. That Kepler himself was fully possessed of this notion is shown by the fact that he conceived a force acting only in the direction of the sun to be insufficient for keeping up the planetary motions, and to require to be supplemented by some force which should constantly push the planet ahead. The latter force he conceived, might arise from the rotation of the sun on his axis. It is hard to say who was the first clearly to see and announce that this notion was entirely incorrect, and that a body once set in motion, and acted on by no force, would move forwards forever—so gradually did the great truth dawn on the minds of men. It must have been obvious to Leonardo da Vinci; it was implicitly contained in Galileo's law of falling bodies, and in Huyghens's theory of central forces; yet neither of these philosophers seems to have clearly and completely expressed it. We can hardly be far wrong in saying that Newton was the first who clearly laid down this law in connection with the correlated laws which cluster around it. The basis of Newton's discovery were these three laws of motion:

"First Law. *A body once set in motion and acted on by no force will move forwards in a straight line and with a uniform velocity forever.*

Second Law. *If a moving body be acted on by any force, its deviation from the motion defined in the first law will be in the direction of the force, and proportional to it.*

Third Law. *Action and reaction are equal, and in opposite directions; that is, whenever one body exerts a force on a second one, the latter exerts a similar force on the first, only in the opposite direction. Popular Astronomy; Page 75.*

And on Page 74, he says: "Gravitation in a somewhat limited sphere is known to all men. It is simply the force which causes all heavy bodies to fall or tend towards the centre of the earth."

This all seems clear enough and certainly excludes gravitation from any part of the office of carrying the planets around in their orbits if words can be made to do so. But Prof. Newcomb, like other writers, is either confused in thought and expression or inconsistent with himself, for in the paragraph last quoted he goes on to say: "What Newton did was to show that the motions of the planets were determined by a universal force, of which the force which caused the apple to fall was one of the manifestations, and thus to deprive the celestial motions of all the mystery in which they had formerly been enshrouded." And again on the same page he says: "The idea of a cosmical force emanating from the sun or the earth, and causing the celestial motions, did not originate with Newton. We have seen that even Ptolemy had an idea of a force which, always directed towards the centre of the earth, or, which was to him the same thing, towards the centre of the universe, not only caused heavy bodies to fall, but bound the whole universe together. Kepler also maintained that the force which moved the planets resided in, and emanated from, the sun. But neither Ptolemy nor Kepler could give any adequate explanation of the force on the basis of laws seen in action around us; nor was it possible to form any conception of its true nature without a knowledge of the general laws of motion and force, to which neither of these philosophers ever attained."

Now taking these latter extracts alone they would seem almost as clearly to teach that the force which carries a body in its orbit is Gravitation, as the former extracts teach the contrary. And this confusion and contradiction of expression in a writer of Prof. Newcomb's great learning and ability shows that there is something contradictory or inexplicable in the received doctrines of solar dynamics; that these doctrines cannot be reconciled with themselves.

On the other hand, Prof. Burritt in his "*Geography of the Heavens,*" *Page 170*, has used language which is entirely in accordance with the system of solar dynamics that I have ventured to lay down. He there says: "Newton was next led to suppose, that perhaps the same power carried the primary planets around the sun. By a series of calculations, he was enabled at length to establish the fact, that the same force which determines the fall of an apple to the earth, carries the moons in their orbits around the planets, and the planets and comets in their orbits around the sun."

On *Page 266*, he says: "The joint action of these two forces gives the planets a circular motion and retains them in their orbits as they revolve." And again on Page, 268; "From the foregoing principles it follows, that the force of gravity and the centrifugal force are mutual *opposing powers* each continually acting against the other."

But that his dynamical notions were confused is shown by the following on *Page* 266: "The degree of the Sun's attractive power at each particular planet, whatever its distance, is uniformly equal to the centrifugal force of the planet. The nearer any planet is to the sun, the more strongly is it attracted by him; the farther any planet is from the Sun, the less is it attracted by him, therefore, those planets which are the nearer to the Sun, must move the faster in their orbits, in order thereby to acquire centrifugal force equal to the power of the Sun's attraction; and those which are the farthest from the Sun, must move the slower, in order, that they may not have too great a degree of centrifugal force, for the weaker attraction of the Sun at those distances."

Laplace seems however to have thought that the original impulse may have been the effect of gravitation.

That the received doctrines are incorrect is demonstrated by the fact that they furnish no reason for the rule of Kepler's Third Law in any of its various expressions. It cannot for a moment be supposed that there can be at least 180 bodies revolving around the sun in times and with velocities all bearing the same precise relations to their respective distances by accident alone. There must be a reason for it, and such reason must be either that the Author of the Solar System took pains at its inception to regulate distances, times and velocities according to the Keplerian law, or else that the character of the forces by which they are moved compels such relationship. If the planets are carried in their orbits by reason of impulses originally imparted by unascertained forces, those impulses must have been accurately measured by the distances of the respective bodies from the Sun: That is the Author of the system, for the sake of harmony, or some other purpose of His own, imparted to each revolving body just that intensity of impulse which would give the requisite velocity to fit it in the groove of Kepler's law. And such would seem to be the notion of Prof. Burritt as I gather it from the last extract. But this is very much like the argument of an early class of geological critics who accounted for fossil remains by supposing that they were created in the rocks as found.

On the contrary, I take it that the reason for Kepler's law must be found in the character of the forces by which the planetary revolutions are produced. Either distances must regulate times or times regulate distances. But the times are the results of motions in the orbits and their duration depends jointly on the lengths of the orbits and the velocities of their motions. But the velocities depend on the intensities of the forces urging them forward in their paths, that is the centrifugal forces.

We have as one expression of Kepler's Third Law:

§ *19. The velocities of the planets are to each other inversely as the square roots of their distances.*

Therefore as times and velocities both correspond to distances, it must be because centrifugal forces correspond to the same. We know nothing about *original impulses*, and therefore we may well conclude that gravitation causes centrifugal motion. Not only so, but we find that the mathematical relationship of gravitation to distance, is precisely the relationship which must exist between centrifugal force and distance, to give the relationship of velocity contained in the above law. Velocities are regulated by distances: How can this be except through the force of gravitation which is in like manner regulated by distances? But let us take twelve different expressions founded on Kepler's Third

Law and the Newtonian Law of Gravitation, as follows:

§ 20. *Times are as the third powers of the square roots of distances.*

§ 21. *Times are inversely as the third powers of the fourth roots of Gravities.*

§ 22. *Times are inversely as the third powers of Velocities.*

§ 23. *Distances are as the squares of the cube roots of Times.*

§ 24. *Distances are inversely as the squares of Velocities.*

§ 25. *Distances are inversely as the square roots of Gravities.*

§ 26. *Velocities are inversely as the cube roots of Times.*

§ 27. *Velocities are inversely as the square roots of Distances.*

§ 28. *Velocities are as the fourth roots of Gravities.*

§ 29. *Gravities are inversely as the fourth powers of the cube roots of Times.*

§ 30. *Gravities are inversely as the squares of Distances.*

§ 31. *Gravities are as the fourth powers of Velocities.*

Now how else can this cluster of mutually dependent laws be accounted for except on the hypothesis that velocities are caused or produced by gravities which are admitted to be regulated by distances? And if this be so what becomes of original propulsion and the doctrine of inertia as applied to planetary motions?

These laws are applicable to a single system, but let us take a law applicable to different systems:

§ 32. As between different systems Velocities are as the fourth roots of Gravities as dependent upon Distances, and as the square roots of Gravities as dependent upon Mass.

Here again we see the necessity of supposing that velocities are dependent upon gravitation and produced by it, that is, that gravitation causes the orbital motions of the planets. The argument could not well be stronger and we take our law:

§ 33. Gravitation is both centripetal and centrifugal force and causes both centripetal and centrifugal motion of the planets in their orbits.

The next inquiry is into the law of the joint action of the two forces so that gravitation may become centrifugal force and that at the same time the two forces may be composited into one. Here regard must be had to the character of the two forces, one a constant force, constantly acting in producing a constant velocity, and the other a constantly received force, which unopposed would produce accelerated velocity at right angles to the other at every point. It is very evident that the two forces must balance each other, but how? If at any point the two were just equal, acting at right angles the planet would move on a line between them and not in a circular path at all; that is the path of the planet would vary 45 degrees from the direction of each of the forces. Now, when it has turned to the same side 45 degrees, eight times at the same distance apart, it will have described the figure of an octohedron and have arrived at the point of departure. And if, instead of eight sharp contacts of force and turnings of 45 degrees each, we suppose the same amount of opposing force distributed through the whole perimeter of the figure we shall have a circle. Therefore the law:

§ 34. When the amount of gravitation received in one eighth of a revolution, just equals the centrifugal force, the two will exactly balance and the path of the planet will be a circle.

Thus, within one eight of its path around the sun, the earth receives gravitation just equal in amount, to the force producing the tangential velocity of 95,000 feet per second, taking that for earth's centrifugal velocity. And when, counting from any particular point in its orbit, it has passed over an arc of 45 degrees, equal amounts of the original tangential force, and of gravity have been expended by resistance to each other; with the result of a composite force, according to the law of the parallelogram of forces. At every point, gravitation acts at right angles to the centrifugal force, with the result of sending earth along the diagonal of a right parallelogram whose sides are respectively represented by the centrifugal force of 95,000 feet per second, and the momentary force of gravitation; and of neutralizing such proportion of the two as the length of the diagonal falls short of the sum of the two adjacent sides. Therefore:

§ 35. The length of an arc of Earth's orbit of 45 degrees may be represented by the diagonal of a square of which the sides are respectively represented by the centrifugal velocity of 95,000 feet per second, and the whole force of Gravitation received in an eighth of a revolution.

§ 36. In a whole revolution there will be eight entire recompositions of force by eight substitutions of gravitation for one half of centrifugal force, with the consequent equal neutralization of the two forces to a total amount equal to 4.6864 times the original centrifugal force.

§ 37. At the end of a revolution one, two hundred and fifty-sixth part of the tangential force is original centrifugal force, and two hundred and fifty-five, two hundred and fifty-sixth parts, substituted Gravitation.

We have seen, that in one eighth of a revolution, just so much gravitation is expended as will balance the tangential force. But this expenditure is continuous, equal amounts in equal times. Therefore we obtain the law, that:

§ 38. The force of gravitation, acting upon a planet in its orbit, is equal to the quotient of the tangential velocity, divided by one eighth of the time of revolution.

By this rule it will be found that Earth's gravity to the Sun is about .024365 feet per second; and the moon's gravity to earth about .010188 feet per second. These quantities are more than twice as great respectively, as those usually given; but, in the first place, the text books take the distance fallen in the first second, instead of the velocity at the end of the second, as the measure of gravity; and, in the next place, the calculations there given are but proximate at best, and in the very nature of the mathematical solutions of the problems, the results are too small.

That the above law is correct, is proven by another expression for Kepler's Third Law:

§ 39. The quotients of the distances, divided by one eighth of the squares of the times of the revolutions, are to each other, inversely, as the squares of the distances.

This is equivalent to saying that gravitation, as found by § 38, is governed by Newton's Law.

To recur to the extract from Prof. Whewell, showing the respective dynamical notions of Kepler and Newton, we would remark that "a perpetual supply of force *is* requisite to keep a body in motion;" that the velocity of a planet is produced by and does exhibit the effects of a force which acts in the direction of motion; that forces do appear in the actual motions which a body has; that they do urge a body forward; if they were destroyed the body would instantly stop; and that a rope pulling a body towards a centre is no correct illustration, so that in every particular Kepler was much nearer right than Newton. Thus on every point of the problem Gallileo had gone back and Newton followed him.

And on another aspect of the case was Kepler much nearer a just conception of the truth than Newton, Galileo or later physicists. That is, as to the true character of the force which causes accelerated motion. Gravity is said to be a continuous or constant force by reason of which bodies fall with accelerated velocity. The notion is, that gravity is a simple, single force, of uniform quantity or volume, so to speak, which constantly initiates new and additional motion, but has nothing to do with that quantity of motion already initiated; instead of the view, that gravity is a constantly received force, equal increments in equal times, and each increment, not only inaugurating a new increment of motion in the body, but entering therein, and carrying on, and continuing such increment of motion, until neutralized, or imparted to some other body. The force imparted by the explosion of gunpowder to a cannon ball, is a constant or continuing force, entering into the ball, and driving it along, until withdrawn, or neutralized, by resistance of the air, or impact with some other body. But Gallileo and his school regard the full office of the explosive force performed, when it has started the ball in motion; and the difference that they see between this force, and gravity is, that gravity constantly adds NEW STARTS to the motion of the falling body.

The whole body of error, goes back to the fundamental notions of force and inertia, held by Gallileo, Newton, and all succeeding scientists, the one notion; that force only INITIATES, or STARTS, and CHANGES motion, but does not continue it, and the other, that INERTIA and NOT FORCE DOES CONTINUE IT. On such a basis of error, a true physical system is impossible; and it is only on such a foundation, that the doctrine of Conservation can stand for a moment.

Because of these erroneous notions concerning the true nature of force, which Galileo taught, and all later scientists have accepted, without question, it is held that the law of the composition of forces ~~are~~ to inapplicable to circular motions. Thus Dr. Whewell, Page 352, Vol. I. says:

"Galileo had convinced himself that the velocity of projection and that which gravity alone would produce, are 'both maintained, without being altered, perturbed, or impeded in their intermixture' It is to be observed, however, that the truth of this result depends upon a particular circumstance, namely, that gravity, at all points, acts in lines, which, as to sense, are parallel. When we have to consider cases in which this is not true, as when the forces tend to the center of a circle, the law of composition cannot be applied in the same way; and in this case mathematicians were met by some peculiar difficulties."

The difficulty is, that at every point in the circle, the centrifugal force tends to urge the moving body past the center of motion on a tangential line; at every point there is a composition of forces, with a tendency to accelerated motion; and, at every point gravity tending to carry the body towards the center, balances centrifugal force, holds the body back from passing the tangential point, and thus neutralizes the tendency to acceleration. The same force which tends to accelerate, at the same time counteracts and destroys that tendency. And, thus, we come to have a composition of forces at every point, without an acceleration of velocity.

e l But in an ellipse, there are only two points at which the motion is tangential to the radius vector; at all other points the center of motion is either ahead of or behind a perpendicular to the line of motion; and the composition of the forces produces, either an actual acceleration, or retardation. Hence it comes, that from aphelion to perihelion there is an acceleration of planetary velocity, and from perihelion to aphelion a retardation.

Now, if only original propulsion is concerned in driving the planets in their orbits, if the only office of gravity is to change direction, if there is no real and true composition of the forces according to the law of the parallelogram of forces, from whence comes this continual acceleration of motion in one half of a revolution, and continual retardation in the other half? Do not all the authorities agree that they are effects of gravitation? And how else can gravitation thus affect them save through the law of Composition? When a planet has lost motion,—call it original projectile motion, if you please,—from perihelion to aphelion how is it to get it back? From whence is it to come? The loss is to be restored from gravity of course; but when restored, what is it, original propulsion or gravitating force? Certainly there can be but one answer, and if the motion of a planet from aphelion to perihelion, and from perihelion to aphelion, is the result of a Composition of forces, of course it must be so at those two tangential points, and would be so were the orbit a circle, at every point.

But this is illustrated by other laws and principles. Thus:

§ 40. If gravitation and centrifugal force should exactly balance at any point in an orbit where the motion is tangential, they will balance at every point, the motion will be tangential at every point and the orbit will be a circle.

That is, if, at any tangential point gravity is just equal to velocity divided by one eighth of the time of revolution the orbit is a circle.

§ 41. If at any tangential point gravity should be greater than centrifugal force, such point is the aphelion of an ellipse.

§ 42. If at any tangential point centrifugal force is greater than gravity such point is the perihelion of an ellipse.

These laws are liable to an apparent exception in this, that if at perihelion, the centrifugal force is very much greater than gravity, as is the case with some comets, the body will be carried in an ellipse so elongated, as to appear a parabola, or hyperbola; and if the aphelion is too near to the central body, or the centrifugal force at that point very much weaker, the foci of the ellipse, one or both, may be within the body of the central sphere, so that the moving body will impinge upon its surface forming one of the same apparent paths.

Baron Humboldt says: "For even in the universe, if the dimensions of the planets, the quantitative admixture of the bodies which compose them, their velocities and distances from one another, were all to increase or diminish in one and the same proportion, all the phenomena depending upon relations of gravitation would remain unchanged in this ideal macrocosmos, or microcosmos." And Laplace as quoted by Humboldt says: "The law of reciprocal attraction, which acts inversely as the square of the distance is that of emanation, proceeding from a center. It appears to be the law of all those forces whose action is perceptible at sensible distances, as in the case of electrical and magnetic force. One ot the remarkable properties of this law is that, if the dimensions of all the bodies in the universe, together with their mutual distances, and their velocities, were proportionally increased or diminished, they would still describe curves precisely similar to those which they now describe; so that the universe, after being thus successively reduced to the smallest conceivable limits, would still always present the same appearance to the observer. These appearances are consequently independent of the dimensions of the universe, as, in virtue of the law of the ratio which exists between force and velocity, they are independent of absolute movement in space." Cosmos Vol. V. Page 16.

Did the above expression require dimensions, distances and times of revolution to be proportionately increased or diminished it would be correct, but it is not as it stands, for if masses and distances should both be doubled or halved in either case velocities would remain constant and with orbits twice or only one half as large and velocities the same the planets would not retain their relative positions nor the Solar System the same aspect for a single hour. The error lies in not making orbital motion the result of gravitating force.

I think now that I have established a doctrine contrary to Conservation in the motions of the planets around their centers and shown that their revolutions are caused by constantly received and constantly neutralized Gravitation. But I claim that axial motion as well, is wholly produced by Gravity and lay down the following law:

§ 43. The doctrine of the Composition of Forces, obtains in the diurnal, as in the annual revolutions of the planets, with a like substitution of Gravity for Centrifugal Force in like arcs of motion, the like neutralization of forces, and the like result of making the whole motion the product of gravity.

It will be understood that gravity towards the center of the revolving sphere is here meant.

This law and the Nebular Hypothesis of La Place lend splendid illustrations to each other, for, assuming the latter to be true, we have the law :

§ 44. At the time each of the primary planets was thrown off, the great nebular sun mass must have been revolving at the same velocity with which the particular planet now moves in its path; and when any secondary was thrown off, its primary must bave been revolving at the speed with which the satellite now revolves in its orbit.

For in each instance, centripetal and centrifugal forces must have then, just balanced each other; because, if the former had been the greater, the planet would have been thrown off earlier, and further out; if the latter had been the greater, it would not have been thrown off at all. As has been shown, the two forces now balance each other. But centripetal force must be the same now, as then, because the distance from the center is the same, and the mass of the central body the same. Therefore, if centripetal force is the same, and distance the same, the centrifugal force neceesary to balance it must be the same, now, as then.

From this and § 19 would necessarlly arise the law :

§ 45. The velocities of the rotating masses of sun and planets about their axes, must have increased as they condensed and contracted, inversely as the square roots of their radii.

But there are objections to this law. The first is the retrograde motions of the satellites of Uranus. This perhaps, may be accounted for hereafter, by finding that the planet itself revolves on its axis in the same direction.

Another objection is, that the diurnal velocity of the sun has not increased according to the law since Mercury was thrown off; and that the same is true of each of the Moon bearing primaries, since their last satellites were respectively thrown off.

Perhaps this may be found to be due to unequal condensation. Gravity does not increase uniformily, according to the law, from the surface to the center; because at any particular depth, the gravity towards the center is in part balanced by the gravity towards the superincumbent mass. In this way, it might happen, that one portion of a revolving mass would act as a break on another portion, or tend to urge it forward, so that the motion of the mass on its axis would be retarded, or accelerated.

Experiments with the pendulum show that gravity varies at different places in the same latitude, consequent no doubt on variable density of the interior. Humboldt in speaking of pendulum observations in the Southern Hemisphere says: "These observations have confirmed a fact which had been strikingly demonstrated in the Northern Hemisphere, namely, that the intensity of gravity is not the same for all places having the same latitude, and that the increase of gravity from the equator towards the poles appears to be subject to different laws under different meridians." Cosmos Vol. V. Page 28.

We have seen that the Moon's gravity to the Earth is .010188. According to the Newtonian law this would give:

§ 46. Gravity at the surface of the Earth towards the center is 40.6982 feet per second.

§ 47. Were the diurnal motion of Earth to cease, bodies at its surface would fall 20.3496 feet in the first second.

Now, taking the Moon's velocity at 3337.702 feet per second, Earth's equatorial velocity should be according to the law, § 18, 25846.11753 feet per second. With such a velocity, her diurnal revolution should be accomplished in 84 minutes 46.7817 seconds. Dividing such velocity by one eighth of such time according to the law, § 38, gives for Earth's gravity 40.6483 feet per second, corresponding so nearly to the result in § 46, as to show that the principles of the calculation are correct.

It follows that at the equatorial surface 8.5316 units of gravity is exhausted in causing Earth's diurnal revolution, while 32.1666 units act as pressure or weight towards her center.

The acknowledged fact that the rotatory motion of a planet weakens gravity towards the center proves that the two forces neutralize each other; that this diminution of force is constant, shows that such neutralization is continuous; and if the exhaustion is continuous there must be a like continuous reception of gravity to supply the place. So, all the facts lead to the same conclusion that diurnal motion is produced by constantly received and constantly exhausted gravity, in contradiction to two propositions of the Conservation theory.

§ 48. Gravitation is a force.

This law, I have elsewhere given in a more generalized form, but its importance demands some further consideration, after so much has been shown of its application.

C. C. Merriman, Esq., in Apr. 1877 No. of Popular Science Monthly, Page 705 says: "The attractive forces, gravity, chemical affinity, and cohesion, whether these forces are many or one, are inherent properties of matter."

Now, if this be so, we have the absurd conclusion, that a property or attribute of any particular mass of matter, may be abstracted, drawn off, and made to do work, or act upon other and distant masses of matter; for such I have shown can be done with gravity or cohesion. This writer makes an attribute or quality perform the office of force, nay even a force itself, for when one body is thrown up by the fall of matter, there can be no difference between the state, or conduct of the former, and of a like body, thrown up with like velocity, by the hand. Yet, the very article from which the paragraph is taken, is written in exemplification of the Conservation of Energy.

Dr. Mayer says, in "The Forces of Inorganic Nature," Page 253, Youman's Edition; "Gravity being regarded as the cause of the falling of bodies, a gravitating force is spoken of, and so the notions of PROPERTY and FORCE are confounded with each other: precisely that which is the essential attribute of every force—the UNION of indestructability with convertibility—is wanting in every property: between a property and a force, between gravity and motion, it is therefore impossible to establish the equation required for a rightly received causal relation. If gravity be called a force, a cause is supposed which produces effects without itself diminishing, and incorrect conceptions of the causal connections of things are thereby fostered. In order that a body may fall, it is no less necessary that it should be lifted up, than that it should be heavy or possess gravity; the fall of bodies ought not therefore to be ascribed to their gravity alone."

Here, Dr. Mayer rejects the proposition that gravity is a force, because, it does not square with the doctrine of the Correlation of forces which his essay is written to establish. Can truth, scientific or any other be reached in this way? Is that to be rejected as force which has all the other elements of force, including "convertibility," because it lacks "indestructability," an attribute, necessary, not to force as force, except in sustaining the integrity of the theory, which the writer is supporting? "If gravity be called a force, a cause is supposed which produces effects without itself diminishing." This sentence contains the gist of the difficulty with gravity. It is seen to be, not only an effect producer, but such without limit or exhaustion; rather than admit that there can, in any way, be a new increment of force, this effect producer and motion maker is conveniently stored away as a property of matter. The proposition, that, because a body cannot fall until it be lifted up, therefore, its fall should not be credited to gravity alone, is just as logical as to say, that a body cannot be thrown upward, until it has fallen, and therefore, the projectile motion upward, should not be ascribed to the muscular effort of the arm alone.

But, it is clear that Dr. Mayer had no conception of the law of the continuous reception of gravity, by all bodies, equal measure in equal times; for, on Page 339, he says: "Gravity being called a force and the same time the term force being connected, in accordance with the common use of language, with the conception of an object capable of producing motion, leads to the false assumption that the mechanical effect (the production of motion) can be produced without a corresponding expenditure of a measurable object. If once the production of motion out of nothing is granted, the annihilation of motion must also be admitted as a consequence."

In "Conservation of Force," Page 368, Youmans Edition; Dr. Faraday says: "There is one wonderful condition of matter, perhaps its only true indication, namely INERTIA; but in relation to the ordinary definition of gravity, it only adds to the difficulty. For if we consider two particles of matter at a certain distance apart, attracting each other under the power of gravity, and free to approach, they will approach, and when at only half the distance, each will have stored up in it, because of INERTIA, a certain amount of mechanical force. This must be due to the force exerted, and, if the conservation principle be true, must have consumed an equivalent proportion of the cause of attraction; and yet, according to the definition of gravity, the attractive force is not diminished thereby, but increased four fold, the force growing up within itself the more rapidly, the more it is occupied in producing other force. On the other hand, if mechanical force from without be used to separate the particles to twice their distance, this force is not stored up in momentum or by inertia, but disappears; and three fourths of the attractive force at the first instance disappears with it. How can this be?"

Prof. Faraday sees the difficulty of reconciling the known laws of Gravity with the theory of Conservation very clearly, and thus attempts to obviate the difficulty. Page 367:

"The principle of the conservation of force would lead us to assume, that when A and B attract each other less, because of increasing distance, then some other exertion of power, either within or without them, is proportionately growing up, and again, that when this distance is diminished, as from ten to one, the power of attraction, now increased a hundred fold, has been produced out of some other form of power which has been equivalently reduced. This enlarged assumption of the nature of gravity is not more metaphysical than the half assumption; and is, I believe, more philosophical and more in accordance with all physical considerations. The half assumption is, in my view of the matter, more dogmatic and irrational than the whole, because it leaves it to be understood that power can be created and destroyed almost at pleasure."

To save the valued theory, he creates in his mind an unnamed and unknown force or power, out of which gravity may be educed, as necessity demands. This is contrary to every logical principle, provided known laws of known forces will account for the phenomena.

Now, upon the laws here insisted upon, it seems to me, that every difficulty vanishes. In the first place gravity is a driving and not a drawing force. Then it is a constantly received force, constantly stored up, imparted, or neutralized as the case may be. At one half the distance it receives four times the force. Why? Because, were it occupying the center of a hollow sphere at the distance of 4 the tendency to move towards every point of the sphere would be equal; now suppose another sphere about it, at the distance of 9, the whole tendency to move out to that sphere would be just equal to the former tendency; but the amount of surface, or the number of points towards which the tendency would exist, would be, relative to the smaller sphere, as the squares of the distances, 81 : 16; that is, the same amount of force tendency would be distributed over surfaces, relatively, as 81 : 16; and, therefore, the tendencies, are as, 81 for the smaller, to 16 for the larger. And when the hollow spheres are removed all save a single point in each, the tendency remains the same, and is converted into actual motion with such relative velocities.

Where does it come from? I do not know, and cannot, in physics, trace its antecedents, any more than its consequents when neutralized; and, as I do not purpose entering the realm of metaphysics, I can offer no explanation of a truth whose demonst/ations press about us like the r
e air we breath; if only, we will permit ourselves to observe them in the logic of common experience, and not for the purpose of supporting a system.

What becomes of gravity when transmitted downwards in the form of pressure? Is it finally neutralized? or is it transformed into some other form of force, as heat, or electricity?

Dr. Stewart, in Conservation of Energ, Page 153, condensing the views of Prof. Helmholtz, in "Interaction of Natural Forces," compares the universe to a candle that is lit and burning out: "Now if this process goes on and always in one direction, there can be no doubt about the issue. The mechanical energy of the universe will be more and more transformed into universally diffused heat, until the universe will no longer be a fit abode for human beings."

The argument is, that solar heat is the source of all mechanical energy; the sun's heat is being continually dissipated, and there is no known adequate source of supply.

We have seen that the first proposition is not correct, though solar heat is such an important factor in the mechanical process of this globe as to determine the fate of life on earth.

Dr. Stewart accounts for the heat of the sun as follows, (P. 151:)—"The most probable theory is that which was first worked out by Helmholtz and Thompson; and which attribute the heat of the sun to the primeval energy of position by particles. In other words it is supposed that these particles originally existed at a great distance from each other, and that, being endowed with the force of gravitation, they have since gradually come together, while in this process heat has been generated, just as it would be if a stone was dropped from the top of a cliff to the earth."

That is, that gravity received during all the slow falling of the particles towards the center is stored up and finally communicated as heat to the mass of the sun. There is no account taken in this theory of the neutralization of gravity by centrifugal force, but the argument seems good, for all the excess of gravity above such neutrlization, by virtue of which the slow fall to the sun is caused, provided we admit that molar force may be converted into heat, of which I have found no demonstration, or, that molecular forces, there as here, may be transformed into heat by percussion.

Let us suppose that all the vast pressure caused by the continuously received gravity in the sun's mass is converted into heat; would not that give us an ample supply to keep the candle burning without wasting? What are the evidences in support of such a theory? I have not found many, for I have failed to find where gravity or pressure is converted directly into heat; but the fact that the pressure is there, and its destiny unaccounted for, and that heat is there and its origin is unaccounted for would seem to make it plausible. In addition to that, we know that gravity may be converted into molar force and molecular force into both heat and molar force. Besides, we have the fact as we should expect, if the theory is good, that the interior of Earth is hot.

§ 49. Molecular Cohesion is convertible into Molar Force.

§ 50. Molecular Cohesion and Muscular Force may mutually resist, balance and neutralize each other.

§ 51. When Molecular Cohesion is metamorphozed or neutralized its place is continuously supplied by the same force, received equal increments in equal times.

1. The above three laws may be illustrated and demonstrated by the example of the cross-bow made of elastic wood. If it be bent by the hands, muscular energy is expended in the work, and because of cohesion, the particles of the timber resist, and the mutual resistance goes on so long as the restraint is continued. Now, in this effort, muscular energy is continuously applied, as is shown by the fact, that soon the hands and arms become fatigued and exhausted. But the resistance of cohesion is just as continuous, for it at no time slackens to the pressure of the hands. That it is continuously exhausted in exertion, is shown by the fact that its cohesion is all the time lessened, so that, if the muscular effort be somewhat increased it will be entirely overcome at the weakest point, and the bow snapped. But if continuously exhausted, it must be in like manner received; and as the strength of the bow does not vary, the increments of reception must be equal in equal times. When the hands are removed, the bow straightens itself by having its ends carried back through space to their original relative positions; the cohesion heretofore exerted in resisting muscular force being converted into molar force with that office.

Dr. Stewart says of the cross-bow, (P. 25) "Let us take, for instance, the force of elasticity, and consider what happens in a cross-bow. When this is bent, the bolt is evidently in a position of advantage with regard to the elastic force of the bow; and when it is discharged, this energy of position of the bolt is converted into energy of motion, just as, when a stone on the top of a house is allowed to fall, its energy of position is converted into that of actual motion.

"In like manner a watch wound up is in a position of advantage with respect to the elastic force of the mainspring; and as the wheels of the watch move this is gradually converted into energy of motion."

Here, his point seems to be, to prove that the muscular energy with which the bow is bent and the watch wound, is not lost; but that it is converted into energy of position, and that into molar force. Now that this cannot be so in the bow, is shown by the fact, that whether the restraint be maintained for a second or an hour, the force of the reaction, and the speed of the arrow will be the same. The exertion of muscular energy for a long time stores, no more energy in the bow, than for a short time.

2. Mr. Spencer, (First Principles Pps. 269, 270) takes an illustration from the vibrations of a tuning fork to sustain the proposition of the universal persistence of force, and attempts to explain it on principles similar to those given of the swinging of a chandelier. After showing

how a prong pulled out of its perpendicular by the finger vibrates when released, he says:

"The force exerted by the finger in bending the prong cannot disappear. Under what form does it exist? It exists under the form of that cohesive tension which it has generated amongst the particles. This cohesive tension can not exist without an equivalent result. What is its equivalent result? The momentum generated in the prong while being carried back to its state of rest. This momentum too—what becomes of it? It must either continue as momentum or produce some correlative force of equal amount. It cannot continue as momentum since change of place is produced by cohesion of the parts; and thus it gradually disappears by being transformed into tension among these parts. This is retransformed into the equivalent momentum; and so on continuously."

Now did muscular energy take the form of molecular tension, and as such, store itself up among the particles of the prong, it would follow that the longer the prong was bent by the finger, the greater would be this tension, and the harder the pull; for evidently, the muscular energy is continually expended as in the instance of bending the bow; because, that after a time, the finger becomes fatigued. But this is not the case, for the rebound of the prong will be as great at the end of a second as of an hour.

The truth is, that when the prong is drawn back, there is an antagonism between the cohesion of its particles and the muscular energy of the finger, each resisting, balancing, and neutralizing the other;—and this continues so long as the strain continues. When the finger is removed, the molecular forces in the prong, continuing to pull as before, are converted into molar force sufficient to carry the prong, not only to the perpendicular, but as far beyond it against the tension of cohesion on that side, until it is exhausted by such resistance. But at this instant, the pull of cohesion on that side, is, in its turn, converted into molar force, in quantity sufficient to carry the prong back to the original point, where, it is, in turn, exhausted by the pull of cohesion on this side, which is, in turn, converted into molar force; and thus the prong vibrates from side to side, cohesion being continually converted into molar force, and in that form, continually resisted and exhausted by cohesion. Evidently, there must be a continuous supply of cohesive force, to take the place of that converted into molar force, as well as that neutralized in resisting it. All vibratory or undulatory action is explainable upon similar principles.

§ 52. Cohesive forces may resist and overcome each other.

When the bend of the bow produced by muscular energy is secured by the bow string, the latter evidently fills the place and office of the hands, with this difference only, that the hands would weary and fatigue, while the string does not. As the muscular energy of the hands antagonized and neutralized the molecular forces of the bow, so, evidently, do the molecular forces of the cord; and as in the former struggle, the molecular forces of the bow are overcome and balanced, so must they be in this. So, also, as the respective cohesive forces of the bow and string continuously neutralize each other, must they each be continuously received.

1. In the instance of the mainspring of a watch given by Dr. Stewart, the coil of the spring is produced by the hand, the cohesive energy in the one, and the muscular energy in the other, antagonizing and balancing each other in the winding of the watch; but when wound up, the place and office of the hand is taken and filled by mechanical contrivances which hold the spring to its tension, loosing it little by little, so as to mark time. The cohesion of the particles of the spring, all the time, resist and is resisted by the cohesion of the parts by which it is held in constraint; and as it is gradually loosed from constraint, the surplus pull of its particles is continuously transformed into molar force, and in this form, imparted to the wheels and hands.

2. The same principle obtains in all mechanical contrivances of cords, bands, bolts, pins, nails and screws, used to hold together different parts of machines and other fabrics.

§ 53. Gravity resists and neutralizes cohesion and is resisted but not neutralized by it.

If, with my arm by my side, I hold in my hand one end of a cord, at the other end of which is suspended a twenty pound weight, my arm will soon become fatigued, which shows that muscular energy is being expended against the gravity of the weight, which is all the time acting against the strength of my arm. And while the muscular energy is dissipated, so that it cannot be traced, and no further account can be taken of it, gravity is not neutralized, but continuously transmitted; as is shown, by the fact, that if, while holding the weight as above, I stand upon a pair of platform scales, they will all the time show a pressure of my own ordinary weight, plus twenty pounds; precisely the same, as though I should lay the twenty pounds on the platform at my feet.

Now, the cord all the time performs the same office as my arm, its cohesion all the time resisting gravity and being overcome and neutralized by it, without the capacity of neutralizing gravity in turn; precisely as with the muscular energy of my arm. And if the weight be sufficiently increased cohesion will be entirely overcome at the weakest point, and the cord will snap.

It will be observed that the strain on the cord is equal at every point, at every point, cohesion resisting, and being resisted and neutralized by gravity.

A pillar of glass might support a slab of marble, weighing a ton, for ages, and yet, be crushed by the addition of a single ounce. In such case, all the time that the marble might be resting there, it would be transmitting the pressure of a ton through the pillar, to the earth beneath. But this pressure would all the time be resisted by the molecular forces of the pillar, which would all the time, be so nearly all neutralized by it, that the additional pressure of an ounce would complete the exhaustion; yet this resistance would not in the least exhaust or retard the continuous transmission of gravity.

In this instance, as in that of the cord, the resistance and neutralization of cohesion is at every point.

§ 54. In all circular, or rotary motion, cohesion is exerted, transformed into centrifugal force, and neutralized by the same.

A ball of clay turned on an axle, swells out into an oblate spheroid and finally breaks in pieces, if the motion is made sufficiently rapid.

Water is thrown off from a turning grind-stone, and, if turned very rapidly, the stone itself may go to pieces.

A cord, to which a stone is attached, whirled rapidly will snap, while the stone will fly off in a straight line.

Now, it is evident, that in each of these examples, centrifugal force is balanced and bent in at every point, from right lines, by the cohesion of the clay, stone, or string, until it becomes the greater, when cohesion will be overcome and neutralized. And, all the time that centrifugal force is being balanced, it balances an equal amount of cohesive centripetal force. But this neutralization of the two opposing centrifugal and centripetal forces, means a recomposition of forces, according to the law of the parallelogram of forces, and the continual substitution of the centripetal force of cohesion, for the centrifugal force.

Thus, if any wheel turning on an axle, be put into rapid motion by the hand, the muscular force is imparted in the form of centrifugal force. Let the hand be taken away, and the wheel will continue to turn for a length of time, Now, at every point, centrifugal force struggles to send the particles off in right lines, and cohesion pulls against it at right angles, so far bending and overcoming it that the particles move in a circle under the law of the composition of forces as explained of the motions of the planets, so that, in one eighth of a revolution, the two forces just equalize and balance each other, cohesion being substituted for one half of the now exhausted initial muscular force. Eight times in one revolution, is this process repeated, so that, very soon, the part of the initial muscular force retained, becomes, almost, infinitely small.

As cohesion is exerted, substituted, and exhausted, of course, its place is continuously supplied, so that, if the wheel could be relieved entirely from friction and the resistance of the atmosphere it would revolve forever.

This is finely exemplified by the swinging of a pound weight attached to a cord. When a velocity of 32 1-6 feet per second is given to the weight, it will fly out to the end of the cord, and move in a horizontal plane, exactly balancing gravity; but all the time exerting a pull or strain on the central pivot or support, equal to a one pound pressure If the weight be doubled, this pivotal pull will be doubled; if the velocity be doubled, the same effect will follow. If the velocity be less than 32 1-6 feet per second, the weight will fail to rise to the plane of the central support, but the pull will be the same, except as to direction. In this instance, gravity will be but partially balanced, and the pull will be partly that of centrifugal force, and partly that of gravity. The principle is taken advantage of and illustrated in the mechanical contrivance called the Governor in the steam engine; and also in the running of mill stones, where the nether instead of the upper stone is made to turn, for if the motion was given to the latter it would tend to lose its weight, and would not press down on the former with sufficient force.

The principle here, is, that the continually received force of gravity, is balanced by another continually received force, to wit: the centripetal force, holding the weight to the pivot and compounding with its centrifugal force.

While gravity is, as we have seen, in various instances continuously resisted, overcome, and neutralized, it is true, that the loss is always compensated. Thus when a stone is thrown upward the projectile force, and the gravity received in the upward flight are mutually neutralized and dissipated; while the latter force, received during the descent, is stored up in the form of motive force, to be communicated to the earth by concussion in the form of pressure. But according to Sir Isaac Newton's expression, of the third law of motion, that action and reaction are equal and opposite, the power, whatever it may be, which generates the projectile force upwards, generates an equal amount downwards, which is communicated to Earth as pressure. The projectile force upwards measures both the gravity neutralized, and the reaction downwards, so that they are exactly equal, and the earth receives precisely that amount of pressure that she would receive, were the stone not thrown upward from her surface at all. But this does not aid the Conservation theory in the least, for there is no transformation or metamorphosis of force, gravity does not transform into the reactionary pressure of the projectile force, for instantaneously with the upward start of the projectile, the opposite reactionary force passes downward through all supports into the earth beneath; while gravity, at that upward start, only commences to be balanced and neutralized by the projectile force, and this process of neutralization, continues all the time of the ascent so that the downward compensating force, is actually passed to and received by Earth, before the compensated force of gravity has been dissipated, and even, before it has been received.

And this law of compensation applies, only when gravity is resisted by other forces than itself. Thus, in the oscillations of the pendulum, accumulated gravity on one side resists and neutralizes gravity during the ascent on the other, and this neutralization is without compensation. So when a stone falls into a pool of water, a part of the accumulated gravity of the descent is imparted to drops of water at the point of impact in the form of upward projectile force; and during their ascent this projectile force neutralizes gravity without compensation. So, also, in the orbital motion of the Moon, its gravity towards Earth is continually neutralized by centrifugal force without any provision for compensation.

§ 55. In combustion, the heat developed is simply the latent or invisible heat holding apart the particles of the fuel and of the oxygen of the atmosphere, which becomes visible, by reason of the fact that since the products of combustion occupy less space than did the elements, there is less call and use for latent heat to hold them asunder.

In the elements certain tensions were to be resisted, and certain amounts of heat were necessary to do it. In the products, the atoms and particles are arranged nearer together, in consequence of which a less amount of heat is needed to resist tensions, and the surplus appears as visible heat. This explanation is not new, but I give it, because

I desire to call attention to the fact, that while Conservationists seem to accept it they do not make fair use of it. If it is a correct explanation, of the phenomena of combustion, it is very evident that far the larger portion of the heat rendered apparent, must be latent in the oxygen; for that, and not the coal, is contracted into smaller space in the act of burning. But, as will be seen hereafter, in dealing with the doctrine of Conservation, scientists treat the subject as though the visible heat were derived altogether from the coal.

§ 56. The heat developed upon the percussion of bodies is due to the transformation of ~~mecular~~ force. molecular

It is hardly necessary to quote authority to show, that the present universally received theory is, that such heat is but the transformation of the molar MOTION, as some put it, or of the force producing that motion, as others have it, with which the body or bodies moved before impact.

Every day experience demonstrates that in impact molar force is communicated from one body to another, WITHOUT ANY SENSIBLE DIMINUTION.

I will take an illustration from Dr. Stewart, (Conservation of Energy, P. 89.) An inelastic body of mass 10 and velocity 20, strikes directly another inelastic body of mass 15 and velocity 15, the direction of both motions being the same. The United mass will, after impact, move with the velocity of 17. "What, then, has been the influence of the forces developed by collision? The body of greater velocity had before impact a momentum of 10 times 20, equal 200, while its momentum after impact is only 10 times 17 equal 170; it has therefore suffered a loss of 30 units as regards momentum, or we may consider that a momentum of 30 units has been impressed upon it in an opposite direction to its previous motion.

"On the other hand the body of the smaller velocity had before impact a momentum of 15 times 15, equal 225, while after impact it has 15 times 17, equal 255 units so that its momentum has been increased 30 units in its previous direction.

"The force of impact has therefore generated 30 units of momentum in two opposite directions, so that, taking account of direction, the momentum of the system is the same before and after impact, for before impact we had a momentum of 10 times 20 plus 15 times 15 equal 425, while after it we have the united mass 25 moving with the velocity 17 giving the momentum 425 as before.

"But while the momentum is the same before and after impact, the visible energy of the moving mass is undoubtedly less after impact than before it. To see this we have only to turn to the expression of Art. 28, from which we find that the energy before impact was as follows:—Energy in kilogrammetres equal the quotient, of the product of 10 into the square of 20 plus the product of 15 into the square of 15 divided by 19.6 equal 376 nearly, while that after impact equals the quotient of the product of 25 into the square of 17 divided by 19.6 equals 368 nearly.

"The loss of energy will be still more manifest if we suppose an inelastic body in motion to strike against a similar body at rest. Thus if we have a body of mass 20 and velocity 20 striking against one of equal mass but at rest, the velocity of the double mass after impact will obviously be only 10; but, as regards energy, that before impact will be the quotient of 20 into the square of 20 divided by 19.6, equal to 8000 divided by 19.6, while that after impact will be the quotient of the product of 40 into the square of 10 divided by 19.6, equal to 4000 divided by 19.6, or only half the former.

"Thus there is in all such cases an apparent loss of visible energy, while there is at the same time the production of heat on account of the blow which takes place."

Now, it will be observed, that in this illustration, Dr. Stewart, tacitly admits that it is necessary to show some loss of visible energy upon impact in order to allow for any of it to have been converted into heat; and this he attempts to do, on his law, elsewhere noticed, that the energy or working capacity of a moving body, is as the square of its velocity; but that proposition, I have shown. § 15, to be untenable; and if there is no loss of "visible energy," there is nothing of molar force that could have been converted into heat, and we have to look elsewhere for its origin.

It will be noticed, that Dr. Stewart seems to use his law above referred to in a different sense in the illustrations of an ascending stone and a rifle-ball. It seems to be assumed, that velocity is proportioned to force, in the one instance, where mass is constant, and inversely to the product of mass into force, in the other, where mass varies. Thus, he would seem to assume, that the velocity of the ascending body is proportioned to the force; and if that is his meaning, then his law would read *where mass is constant, visible energy or working power is as the square of the force acting.* So, he seems to assume in the rifle illustration, that the respective velocities of the ball and stock are, as the products of mass into force, or, rather as to mass, for here force is constant, and if that is his meaning, his law would read, where force is constant and mass varies energy or working power is as the square of the mass, but where both mass and force vary, it is as the square of the product of mass into force.

But in these illustrations from the impact of bodies, he seems to mean, that it is *force itself* which is as the square of velocity; that is, that it takes four times the force to produce double the velocity, and nine times the force, to produce triple the velocity; for such is certainly the only logical deductions from the illustrations. And this is exactly the proposition of Prof. Newcomb, who says: "The force required to impress a given velocity on a body falling through any distance is proportional to the square of the velocity, four times the force being required to give double the velocity, nine times to increase it three fold and so on."—Pop. Ast. Page 487.

But let us see what really takes place, upon impact. In the first example given by Prof. Stewart, the larger body moves under the influence of force 225, for momentum, the product of mass into velocity is the measure of force, and the smaller body under force 200. Upon impact the smaller body, with the greater velocity, imparts force 30 to the larger body, with smaller velocity, and the latter receives what the former imparts, so that the united mass moves with the same velocity 17, but the measure of force in what before constituted the smaller but swifter body, is 30 less, and in the other, 30 more, 170 and 285 respectively.

Now, it is evident, that there is no generation of force or momentum here, no loss or gain, but simply an equalization. It is therefore inaccurate to say, that "a momentum of 30 units has been impressed upon the smaller body in the opposite direction;" it has simply lost force, and with it momentum by impartation. It is, also, inaccurate to say, that, "The force of impact has therefore generated 30 units of momentum in two opposite directions;" for there has been nothing generated; force has been communicated and received, and motion consequently lost and gained. There is a reduction of motion in the transferer of force, and an augmentation of the same in the transferee.

Nor does the example illustrate Sir Isaac Newton's rendering of the third law of motion, for which Dr. Stewart introduces it, to wit: "Action and reaction are equal and opposite, so that when two bodies come in collision the forces at work generate equal and opposite quantities of momentum," for there is no reaction in the case, and no opposite momentum generated.

Now let us suppose the two colliding bodies moving in opposite directions and see what is the result. Evidently the smaller body will lose all its forward motion, but the larger one will not. The explanation is that the force, 200, of the smaller body will all be neutralized, but it will at the same time neutralize the same amount of force in the larger body, leaving 25 residuary units; and this remaining force will be equalized throughout the united mass, so that the whole will move in the direction of the motion of the larger body, with a momentum of 1.

If the two bodies collide at an angle, the forces will be equalized, and the united mass will move in a direction, and with a velocity, determined by the law of the parallelogram of forces; all the residue of force, above what is necessary to produce such motion, being neutralized in the collision. In such case, equal quantities of force from the two bodies are neutralized.

Dr. Stewart's second illustration, shows that in impact, of a moving body against one at rest—unattached to the earth, the law prevails, force is imparted on the same principles. So, also, when a body, large or small, with whatever velocity, collides with the earth or any object firmly attached thereto, the same impartation and neutralization of forces take place, under the law of the parallelogram of forces.

We fail, then, to find, that molar force is converted directly into heat, for it is all, either accounted for, or neutralized in percussion, according to the direction in which the colliding bodies move. And, I do not regard the experiments of Joule and others, as satisfactorily settling this question, since no account was taken of molecular forces, and the possibility of their having been the origin of the heat evolved.

In the illustrations of the bow and tuning fork, we have seen how that when the constraint is removed from the tension of cohesion in them, molar motion is instantaneously produced. If an elastic ball be thrown against a wall, the motion of the forward side, being suddenly arrested, the particles farther back are driven by the molar force, forward in and upon the particles in front, against the resistance of molecular forces; by which resistance the molar force is balanced and neutralized, when, the molecular forces relieved from this tension, are metamorphized into molar force, carrying the ball off from the wall.

But, if a ball of clay, or putty, be thrown, the molucular forces are overcome, and neutralized by the molar force, the particles are broken apart from each other, and the ball is flattened against the wall.

When a stone is thrown, motion is suddenly arrested as before; the particles farther back tend to rush in upon the forward ones; there is the same resistance, but the effect is different; the stone neither breaks and flattens, nor flies off; the blow on the wall is much harder and heat is evolved.

We have seen how, in the form of pressure, gravity is transmitted downward without diminution, though all the time resisted by and neutralizing cohesion. So, here, the molar force of the stone, though resisted by coetaneously neutralized molecular forces, is transmitted undiminished to the wall. Now, at the moment the molar force is all communicated to the wall, the constantly renewed, still acting molecular forces, left without a neutralizing balance, not broken by the disruption of the particles, as in the ball of clay, not able to generate opposite motive force, as in the rubber ball, are converted into heat.

So, if the wall be inelastic, there is the same strain on the molecular forces where the ball strikes; it is passed off and forward as a throb of pressure, and the relieved cohesion explodes, so to speak, into heat. We must suppose that upon pressure, percussion, or other strain, molecular forces are called into resisting action to the full equivalent of the counteracting force, or the limit of the cohesive tension of the particular substance, whichever is first reached. If it is the latter, cohesion is destroyed and lost, and the body breaks or crumbles; if the former, cohesion constantly resists, is exhausted in resisting, and is constantly renewed until the opposing force is withdrawn, when, there being an unneeded surplus above the ordinary uses of the particles of the body, this surplus of force must be and act in some form, until neutralized; in elastic bodies it becomes molar force, in inelastic bodies, heat. But as no body is perfectly elastic, or perfectly inelastic, upon every percussion, it takes on more or less of both forms.

Friction may be considered as being an almost infinite number of small coetaneous collisions between the particles of the rubbing bodies, and the evolution of heat thereby is explainable on the same principles.

The argument may be thus stated: Before impact we have two modes of force, motive and molecular to deal with. Upon impact, a third mode, heat, appears. Whether is it a metamorphosis of the recent molar or molecular force is the question? That it is not of the former, is shown by the fact, that it is all either neutralized or transferred without diminution. It can be accurately accounted for by the law of composition of forces Dr. Stewart's supposed law of the multiplication of energy according to the squares of velocities, we have seen to be untenable, and therefore, incapable of rendering support to the hypothesis. We are driven therefore to the other alternative. Molecular forces must correlate with heat upon impact. And this seems to harmonize with the facts, that the latter are constantly received forces, which may, and frequently do, metamorphose into motive forces.

Dr. Stewart says: "If a kilogramme of water be dropped under gravity from a height of 424 metres, the velocity which it acquires, will, if wholly converted into heat raise its temperature one degree C. Farther if it be dropped from twice this height, its temperature will be raised 2° C , if from three times the height 3° C., and so on." Elementary Physics, Page 206.

The first thing to be observed in this paragraph is the usual inaccuracy of language in handling the subject, making VELOCITY metamorphose into HEAT. The next thing that I would observe is that if molar force ever passes into heat at all, certainly it never did in any instance and never will wholly so metamorphose. But what I desire to notice more particularly is the numerical inaccuracy of the conclusion arrived at. A fall of 424 feet gives a final velocity of 165.16 feet while a fall of 848 feet gives a final velocity of only 223.56 feet. Final velocity measures the gravity received, that is the whole force available for convertion if convertion be possible. Therefore if a fall of 424 feet would give one degree, then a fall of 848 feet could give but 1,35 degrees instead of two degrees as given by Dr. Stewart, while a fall three times as great would give a final velocity of 286.3 feet and 1.73 degrees of heat.

The error is the old one of taking the distance fallen instead of the velocity attained as the measure of force.

Another argument against the doctrine of the Convertion of molar force into heat is found in the fact that it is only near the surfaces of collision that it is generated. The hatchet head is heated in hammering but the ~~back~~ Head is not. If the heat was but the transformation of checked molar force, there appears no reason why one part should not be heated as readily as another.

§ 56. In the Steam Engine the power manifested is produced by the transformation of Molecular forces.

The steam presses all the time against every part of the interior walls of the cylinder of course, without any loss of its heat force, no matter how long the pressure continues. At the same time, there is necessarily a counter pressure or resistance by the cohesive forces of the cylinder walls, the one side resisting and pressing the steam against the other, and the reverse, something as the molecular forces of the bow and string resist each other.

But the molecular forces of the metal, while continually resisting and exerting themselves, are continuously neutralized and renewed, as shown by the fact, that the cohesion of its particles may be so nearly balanced, for any length of time, that the addition of another pound of steam, completely overcomes it and tears the cylinder in pieces. Now, while the cohesion of the walls, press in from every direction against the out-pressing steam, the adhesion of the piston rod to the walls being less than this pressure against the steam, it gives way, and, the surplus in-pressing cohesion, being relieved somewhat of the opposing strain, goes out as molar force, acting through the steam, against the piston, like as through the piston it pushes against outside obstructions. But the force thus transmitted as molar force, is continuously renewed as molecular force.

If the withdrawal of the inside pressure, should, from any cause, be sudden and great, the in-pressing cohesion being thus suddenly relieved of the opposing tension, would take the form of molar force, perhaps, rending the cylinder in an explosion.

This view corresponds with what we have every where seen to be the action of molecular forces, where resistance to them is withdrawn. To meet and balance the resisting forces, molecular forces are called upon to do extra work, and to make extra expenditure, and, when the resistance ceases, the extra cohesion called but not used, must have work to do until the call and expenditure can be equalized, which takes time, and if it does not find room and office as another force, it shows itself as heat.

Of course, the amount of either molar force or heat thus evoked, must correspond very accurately in measure, to that of the opposing forces that it is called out to resist. If heat is the result of resisting molar force, the heat should correspond in measure with the molar force resisted; since the molecular force resisting and transformed into heat is just its equivalent. So if molar force is developed by resistance to heat, the molar force and heat should measure each other; since each measures the resisting transformed molecular forces.

The problem for solution in the action of the steam engine, is to ascertain which force it is, heat or cohesion, that is transformed into molar force. Both forces are present resisting each other—is a portion of the heat converted into working force? or is it the molecular forces called out for extra work against the steam pressure, that, upon being relieved from the tension of this extra work, rush into the molar form? The problem is difficult, particularly so, because both forces are present in any experiment that can be made, and heat always there in two interchangeable forms. For, if upon the expulsion of the piston, there is a loss of visible heat in the steam, how can it be shown that the apparent loss is not simply a change into the latent state?

But we may gain some instruction from the action of the air gun. I compress the air in it by the expenditure of muscular energy; heat is evolved. Where does it come from? The full amount of the muscular energy acts through the column of air on the walls of the gun; that is not converted into heat. The heat capacity of the air is lessened by compression, a portion of its latent heat becomes sensible. But, be that as it may, this extra sensible heat will soon be conducted away by the gun barrel, and then we have simply a column of compressed air of the same temperature as the surrounding atmosphere.

Now certainly the energy of this column of air does not depend upon any heat received by the compression; for its visible heat is the same, and its latent heat less than before compression. Let a stop-cock be turned upon it, and we have for any length of time, a struggle between the expansive force of the air, and the cohesion of the particles of the barrel; just as we had a struggle between the molecular forces of the bow, and of the string; and this struggle we may maintain so long as we please; the molecular forces of the metal being continually neutralized to the extent of the extra tension necessary to resist the inside pressure, and continuously renewed to the same extent, but the forces in the column of air remaining the same. The air is turned upon the bullet and it is driven out with great power. What drives it out? that is what portion of the contending forces, enters into it and carries it in its flight through the air? The forces in the compressed air? If so, it would lose its expansibility, would it not? These forces are struggling all the time to do what? To carry the particles of the column of air to their normal distance asunder—to place them relatively to each other where they were before compression took place. And do they not do that thing instantaneously? Do not the particles rush apart, just as they have all the time been struggling to do? What is it that carries them apart, if not the forces that all the time have struggled to do so? And will it not take the same measure of force to carry them asunder, that was employed to resist their compression? It seems to me, that even the doctrine of CONSERVATION, necessitates the belief that it has been the same forces in the same measure all the way through, holding the particles asunder, resisting compression, driving them apart upon their release, and again holding them so. If so, we shall have to look elsewhere to find the origin of the force which drives the ball. That I find, of course, in the suddenly released, extra forces of cohesion, in the particles of the barrel. It would seem strange if the forces which had been struggling, for days it might be, to separate the particles of confined air to their original distance, should, at the very instant of their release, instead of doing the work they had so long been endeavoring to do, metamorphose into another form to do another work.

In the explosion of gun-powder, in gunnery, we have the same principles in part illustrated. The powder unites with the oxygen of the atmosphere in combustion, the new compound being much more expansive than the old ingredients; the particles, therefore, struggle to rush apart by virtue of the repulsive forces in them; they are antagonized by the cohesion of the particles of the gun barrel, the ball is forced out, and the particles of the newly formed substance rush away from each other, carried, of course, by the repulsive forces generated in them. But where does the force which carries the ball originate? Is it a part of the force that was pushing against the gun barrel to get room for the expansion of the newly formed gas? If so, how is it that when free to act, it does not still push away the particles? And, as in the former illustration, here, again, of course, the forces struggling to free and expand the gas to its normal condition, are the forces that would have to be overcome in reducing it back to the condition it was in, before the spark was applied. That is, the force which holds the particles of the gas asunder, is of the same measure as that which carried them asunder, which struggled against the metal walls, and which would have to be overcome in retransforming the gas into powder and oxygen; so that, there is nothing to spare as motive force to carry the ball; thus leaving us to look to the cohesion of the metal for such force.

Going back now to the steam engine, when the piston is driven out, the struggling particles of steam get as far away from each other as possible, filling up the vacuum; if an escape valve is opened the steam rushes out with great power to a considerable distance, and the particles then get away from each other; if a boiler bursts the steam spreads out with great force and to a large volume, Now what is to be noticed here is, that with the steam, as with the compressed air, struggling to expand itself, its particles do rush away from each other when permitted, even to the filling of a normal volume. What drives them apart? Heat of course; heat that is in them gives them motion away from each other, and goes with them in the motion. Is a part of this converted into molar force? If so it does ~~less~~ more than it struggled to do, that is, steam at a certain temperature, required a certain amount of space for its occupancy, it has just heat enough in its particles to carry them far enough to fill such space; it struggles to carry them to its limits; it is resisted; finally the resistance ceases, and the heat does what? drives apart the particles to which work it is just equal? or metmorphoses itself into another force to do another work? We know it does the former, we know it drives the particles asunder; just what it was equal to; why should we say that a part—a very large part of it is at that moment transferred out of the steam into the cylinder and metamorphosed from heat into molar force?

§ 57. Heat is a mode of Force.

This is the sense in which I have used the word, but as it is by high authority defined otherwise, I thought well to notice it further here. Thus Prof. Grove in "Correlation of Physical Forces," Page 40, says: "Heat thus viewed, is motion." Dr. Stewart says that it is "a species of motion." "In the argument now given, we have only two alternatives to start with—either heat must consist of a motion of particles, or, where percussion or friction is converted into heat, a peculiar substance called caloric must be created, for if heat be not a species of motion, it must necessarily be a species of matter. Now we have preferred to consider heat as a species of motion to the alternative of supposing a peculiar kind of matter." (Conservation of Energy, P. 40,) Prof. Newcomb says: "It is now established that heat is only a certain form of motion."

Here, as elsewhere, these great thinkers, like most others who have written on the subject; fail to accurately distinguish between Force and Motion, sometimes saying the one when they really mean the other, and often leaving it difficult for the reader to determine which, really, is meant. Prof. Grove in several places classes motion as a species of Force with Heat, Electricity. Light, Magnetism, and Chemical-Affinity. Herbert Spenser speaks of motion set up in any direction being a cause of other motion in the same line. Now, when it is remembered that Motion is simply a change of place, or position, in space, it will be seen that confusion of thought is bred by this inaccurate and indiscriminate usage of terms. For, no one means by Heat, the manner of the change of place, but the power by which such change is determined, educed or caused. But the above quotations show that scientists generally have no very distinct notions regarding the true character of either force or motion.

§ 58. Heat neutralizes Molecular Forces.

Heat is present as a repulsive force in the particles of all known matter tending to drive them apart, holding a continual struggle against molecular forces, the latter sometimes preponderating when the particles will cohere in the form of a solid body, the former sometimes the more powerful when the substance will exist as liquid or vapor. The difference in the two forms of force is that heat is a constant force never neutralized but continually ebbing and flowing through matter while molecular forces are constantly neutralized, and as constantly received. In a piece of ice, at 31 degrees heat may struggle against cohesion for weeks, at 33 degrees it overcomes; all the time of the struggle it is neutralizing it.

§ 59. In vegetable life there is, within, a directive principle which takes hold of, uses, and controls the forces of inorganic nature in the building up of the individual plant.

It is held that the forces used in vegetal growth are all correlations of solar heat. Mr. Spencer says, (Frst Principles, Page 209:) "Thus the irresistible inference is, that the forces by which plants abstract the materials of their tissues from surrounding inorganic compounds—the forces by which they grow and carry on their functions, are forces that previously existed as solar rays."

Dr. Carpenter says: "Hence we seem justified in affirming that the correlation between heat and the organizing force of plants is not less than that which exists between heat and motion."

Prof. LeConte says: (Conservation of Energy, Page 177,) "It would seem in this case, therefore, that physical force (light) is changed into nascent chemical force, and this nascent chemical force, under the peculiar conditions present, forms organic matter, and reappears as vital force. Light falling on living green leaves is destroyed or consumed in doing the work of decomposition; disappears as light, to reappear as nascent chemical energy; and this in its turn disappears in forming organic matter, to reappear as the vital force of the organic matter thus formed."

There is no question that the solar rays supply a very important factor in the plant developement, but it cannot be shown that all the forces of vegetal life are thus derived. Capillary forces fill a large office, in extracting nutrient material from the soil, and carrying them into the branches and leaves of the plant. Chemical and molecular cohesion are other large factors in vegetable life processes. One office, at least of the solar rays, is to resist, overcome and neutralize, chemical cohesion in certain compounds, as carbonic acid, whose elements are needed in the construction of the various products of vegetal life. These decomposed elements enter into new combinations, by reason of the forces of chemical cohesion; and these new compounds unite by virtue of the forces of molecular cohesion, to form the various tissues and organic parts of the plant.

Now I think that it has never been and cannot be shown, that any of these forces are correlations of solar forces, any more than it can be shown that Gravitation is such a correlation. They are forces which are always present, and always act, when the proper conditions are presented, whether such conditions have been produced by one cause or another. Their antecedents cannot be traced, any more than can the antecedents of gravitation. We have heretofore, seen, that molecular force is a constantly neutralized and a constantly received force. This is well illustrated in the undulatory waving of trees, and other plants before the winds. These cohesive forces of the plant resist the pressure of the atmosphere, are overcome by it to a certain extent; but, finally overcoming it carry the stem of the plant back to the perpendicular, and, in doing so, generate motive force sufficient to carry it on back against the pressure of the wind, as well as against the now resisting cohesion, until such motive force is in turn overcome, and the plant is again carried forward by the wind, and by molecular force, converted into motive force, in the former direction.

But it is very clear, that these forces are all resisted, and to a greater or less extent, overcome by gravity. Capillary force acts directly against gravity, overcoming it to an extent, and being overcome by it. The cohesion of particles enables the limbs of trees to resist gravity; the two forces mutually counteracting each other, and cohesion being continuously neutralized and renewed.

All the forces of vegetable life are, therefore, but the ordinary inorganic forces of nature, solar forces, capillary forces, atomic forces, molecular forces, etc., laid under contribution, and pressed into service in the developement of the plant. There is no "vital force," then, which takes hold of the nutritive elements and builds them into a living organism. What is there? What Dr. Carpenter calls a "DIRECTIVE AGENCY," a principle which takes hold of these ordinary inorganic forces, and uses them as its servants, in doing its work of plant making.

Dr. Carpenter says, speaking of this principle as found in the plant germ: "The special attribute of the vegetable germ is its power of utilizing after its own fashion, the heat which it receives, and of applying it as a constructive power to the building up of its fabric after its characteristic type."

But what is this principle? What is its character and nature? I answer:

§ 60. A Personal Intelligence within the plant.

I define it an Intelligence, because it does intelligent work. It takes up rude nutriment from the soil, carries it to the leaves, decomposes it, and recombines it with materials taken from the atmosphere into wood, bark, fiber, starch, sugar, and a thousand other things, nutrient, innocuous, or virulent, and builds them, particle by particle, into root and stem, and branch, and leaf, and flower, and fruit, just when and where, and how, it is fit and proper. No architect, with compass, and rule, and material furnished, molded and hewn to his hand, ever built or planned edifice, so intricate, grand, and wonderful as any one of a thousand plants of garden, field, or forest. When it is shown that something else in the universe than intelligence, can do intelligent acts, it may be time to doubt that intelligence builds the plant.

By a personal intelligence, I mean an intelligence that is individualized and independent, having a separate and definite identity, which would be what it is though all other intelligences were annihilated. For illustration, each stalk in a field of corn grows as though it were the only stalk in existence; annihilate all other corn, and all other vegetation, and this plant will survive, and its intelligence, will go on perfecting the structure just the same.

I say intelligence WITHIN, because intelligence, like forces, acts where it is present, and not at a distance.

We have here, then, a higher principle; something above the forces of nature; something laying hold of them, organizing, controlling, molding, and using them on a plan, for a purpose, to an end. It is a vital principle, but not a vital force; and if it correlates any force of plant life as Dr. Stewart and Mr. Spencer claim, a wider scope must be allowed to the doctrine of Conservation. For not only must forces metamorphose into each other, but into another and higher mode of being as well. This is a point which cannot be carried by assumptions; evidence must be brought to its support. But if the hypothesis is not correct there results a hiatus in the correlation of solar forces in the plant.

But the doctrine is presented in another aspect. It is said that sun heat is stored up as energy of position in the plant fibers to be afterwards evolved as heat in combustion at such times as the vegetable fibers may be used as fuel in the form of wood or coal.

In Conservation of Energy, Page 143, Dr. Stewart says: "Fuel is of two varieties—wood and coal. Now, if we consider the origin of these we shall see that they are produced by the Sun's rays. Certain of these rays; decompose carbonic acid in the leaves of plants, setting free the oxygen, while the carbon is used for the structure or wood of the plant. Now, the energy of these rays is spent in the process.

"We thus see that the energy implied in wood is derived from the Sun's ray's, and the same remark applies to coal.

"We are, therefore, perfectly justified in saying that the energy of fuel is derived from the Sun's rays."

Prof. Liebig says: "Without the light of the Sun plants cannot grow. The living germ, the green leaf, owe to the Sun their power of transforming earthly elements into living, vigorous structures. The illuminating and heating rays of the Sun, in thus bestowing life lose their own light and heat. Their power now becomes latent in the new products of the frame, which have been produced under their influence from carbonic acid, water and ammonia. The light and heat with which our dwellings are illuminated and warmed are but those bestowed by the Sun."

Now, in combustion, by far the larger part of the heat generated is derived from the oxygen of the atmosphere. So that the proposition under consideration can be, but very partially, if at all, true. At most, it is a pretty but unproven theory of possible limited application.

§ 61. The vital principle in a plant, while individual and independent, may at the same time be aggregated of any number of individual intelligencies.

In the apple tree, for instance, each branch and bud has, to a certain extent, an independent and individual life; for it may be detached, and made to grow into an independent tree; but while attached, it helps to make the life and growth of the parent tree.

§ 62. The intelligence of the growing plant, organizes other intelligences like itself, and wrapping them in seeds and kernels, lays them away with the possibilities of myriads of other like intelligences in them.

§ 63. The individual intelligence of a single plant, while acting on one general plan, or type, may, at the same time, work out several individual varieties of such plan.

Thus, several manners of apples may be seen, growing together, on one tree from buds or grafts from other trees; the intelligence in the several branches, working together on one general plan, but at the same time, on diverse but kindred individual types. But the tree will not bear walnuts, because the two types are so far varient, that they cannot be worked into one general plan.

§ 64. The inorganic forces, taken up and used in plant life, so far as they are not neutralized in the using under laws already given, are either returned as received, or metamorphosed into others.

§ 65. Neither the antecedents nor consequents of plant intelligences can be traced in physics.

§ 66. In animal life, there is a two fold or bilateral intelligence, one side unconscious, and the other conscious.

The former is very analogous to plant intelligence, its office being to mold and use the forces of nature to the purposes and ends of the developement and well being of the individual, and the propagation of its kind.

On the other side, not only is there the higher principle of consciousness to distinguish it, but also, the processes of thought, together with the faculties of volition and feeling.

The two sides, while partially independent in the same individual, are at the same time, intimately dependent, interactive, and reactive upon each other.

It is claimed that physiological and muscular forces are derived from solar rays. Thus Prof. LeConte, in Conservation of Energy, Page 199, says: "Force is only transferred and transformed. The plant draws its force from the Sun, and therefore what the plant gains the Sun loses. Animals draw from plants, and therefore what the animal kingdom gains the vegetable kingdom loses.

"Finally, as organic matter is so much matter taken from the common fund of matter of earth and air, embodied for a brief space, to be again by death and decomposition returned to that common fund, so also it would seem that the organic forces of the living bodies of plants and animals may be regarded as so much force drawn from the common fund, of physical and chemical forces, to be again all refunded by death and decomposition."

And Mr. Spencer, says, First Principles, Page 209: "That animal life is immediately or mediately dependent on vegetal life, is a familiar truth. And while the decomposition effected by the plant, is at the expense of certain forces emanating from the Sun, which are employed in overcoming the affinities of carbon and hydrogen for the oxygen united with them; the re composition effected by the animal, is at the profit of these forces, which are liberated duing the combination of such elements. Thus the movements internal and external, of the animal, are re-appearances in new forms of a power absorbed by the plant under the shape of light and heat. Just as, in the manner above explained, the solar forces expended in raising vapor from the sea's surface, are given out again in the fall of rain and rivers to the same level and in the accompanying transfer of solid matters; so, the solar forces that in the plant raised certain chemical elements to a condition of unstable equilibrium, are given out again in the actions of the animal during the fall of these elements to a condition of stable equilibrium."

Prof. Liebig says: "The elements of the food of men and animals which give rise to power and heat are produced in living plants only by the action of sunlight. The rays of the Sun becomes latent, so to speak, in them in the same way as the current of electricity becomes latent in the hydrogen by decomposition of water.

"Man, by food, not only maintains the perfect structure of his body, but he daily lays in a store of power and heat, derived in the first instance from the Sun. This power and heat, latent for a time, reappears and again becomes active when the living structures are resolved by the vital processes into their original elements.

"The rays of the Sun add daily to the store of indestructible forces of our terrestrial body, maintaining life and motion. Thus, from beyond the limits of our earth, the body, the more earthly vessel, derives all that may be called good in it, and of this not a single particle is ever lost."

We have already seen, that the hypothesis that the solar rays are stored in vegetable fiber, to reappear as heat in combustion, is without evidence to support it; and is, at best, but limitedly true. The proposition that such forces are stored in the albuminous products of plants, stands on the same basis. And, if admitted, it does not demonstrate by any means, that they are converted into the forces of animal life. It seems highly probable, that animal heat is evolved by a kind of combustion, and if so, it comes more from the oxygen, than from the food products with which the latter may unite. But there are various other forces used in the animal economy, as capillary action, exosmose, endosmose, chemical and molecular cohesion, electricity, etc. As was remarked in regard to vegetation, these are forces always present and ready to act upon the atoms and particles of matter, under appropriate conditions, no difference by what means such conditions are evoked. Their antecedents cannot be traced; they act against gravity, and are variously neutralized by such action and resistance, and in the same measure renewed. But in the animal, there is a new character of energy. muscular force, evolved immediately by the contraction of muscular tissues. What causes such contraction? It would seem to be molecular cohesion or something near of kin to it. That it is not a metamorphosis of heat, would seem to follow from the fact, that muscular action is always accompanied by an evolution of visible heat, and the more violent the action, the greater the heat apparent.

Muscular action, like all other physiological functions, seems to be the resultant of ordinary natural forces, acting under an individualized directive agency, as in the plant. This agency is not a force, as we have already seen, but a higher principle, controlling and using natural forces, to definite ends.

§ 67. In the animal as in the plant neither the antecedent nor consequent of the intelligent or vital principle can be traced in physics.

In First Principles, Page 217, Herbert Spencer says: "Various classes of facts thus unite to prove that the law of metamorphosis which holds amongst the physical forces, holds equally between them and mental forces. Those modes of the unknowable which we call motion, heat, light, chemical affinity, &c?, are alike transformable into each other, and into those modes of the unknowable which we distinguish as sensation, emotion, thought: these in their turns, being directly or indirectly retransformable into the original shapes. That no idea or feeling arises, save as a result of some physical force expended in producing it, is fast becoming a common place in science; and whoever duly weighs the evidence will see, that nothing but an overwhelming bias in favor of a preconceived theory, can explain its non-acceptance. How this metamorphosis takes place—how a force existing as motion, heat, or light, can become a mode of consciousness—how it is possible for aerial vibrations to generate the sensations we call sound, or for the forces liberated by chemical changes in the brain to give rise to emotion—these are mysteries which it is impossible to fathom. But they are not profounder mysteries than the transformations of the physical forces into each other. They are not more completely beyond our comprehension than the natures of Mind and Matter. They have simply the same insolubility as all other ultimate questions. We can learn nothing more than that here is one of the uniformities in the order of phenomena."

The argument to this conclusion is too long to quote, but it is this, in short, that every mental effort, thought, feeling, or volition, is accompanied by chemical and other changes and motions, in blood and brain, and bears a definite relation thereto; that is, that such mental action results upon the expenditure of definite portions of physical energy.

Now granting the premises, which seem to be well established, does the conclusion follow? And a more profound inquiry cannot be instituted; for, if Mr. Spencer is correct, the mind becomes, at best, a mere abstraction.

In the outset, I may remark, that it will be admitted that there is strong reason for doubting Mr. Spencer's logical accuracy, when it is observed, that in this very extract, he confounds force and motion; classing the latter with the forces, heat, light and chemical affinity, as we have seen Prof. Grove doing, and as Dr. Youmans does in his introductory to Grove's work.

Now let us see what takes place in the brain. Certain physical forces act, producing motion, change of place in its particles. How? As all other motion is produced, the forces entering into and moving the particles. What become of the forces after the particles are moved, the change of place accomplished? They may be neutralized by counteracting forces, or they may be communicated to contiguous teguments and walls, just as may happen to similar forces in similar masses of dead matter. But something else takes place cortaneously—sensations, Cr emotions, volitions. Mr. Spencer says, a force existing as motion, heat, or light, is transformed into the thought, emotion, or volition. Now force produces or causes motion; it is not transformed into motion. Heat produces and measures motion, but is not motion, and not metamorphosed into motion. Why shall it be said, that although a force can produce motion, without becoming motion, yet it cannot produce an emotion, thought, or volition without becoming such? Certainly there is no logical necessity for any such conclusion in either case.

But is it clear, that the action in the brain matter of chemical or other forces, produces or causes the mental action at all? May it not be that this action in and upon the brain, is not the cause but the occasion of the thought or feeling? It does produce one effect, the only effect that it can produce on other masses of matter, MOTION; are we under the necessity of thinking, in this case, that it has a double effect? a two fold action, one like its ordinary action on other matter, and the other extraordinary and peculiar to brain matter? There is no contradiction in supposing the action of one independent force, to be the invariable occasion upon which another independent force acts. Thus, we may suppose that these chemical forces, acting upon the brain, by reason of some inherent attribute or law independent of the mind, is nevertheless, taken by the mind, as the monitor or director of its actions, which, when these forces act in a certain way, takes occasion thereupon to think, and when they act in some other certain way, takes occasion to will, and so on.

But is it necessary to think that these forces do act independent of the mind at all? Is it not logical to suppose, that, when the mind would use the brain in thinking, or willing, or feeling, it calls these forces into action, uses them for its purposes, and then dismisses them; just as when it would use the hand in writing, it summonses forces in the form of muscular contractions and relaxations, and puts them to work, and keeps them at it until it is done with them or they are exhausted? In either case the amount of force used would be the measure of work done. Of course I use the term Mind here as representing man's dual intelligence.

But admitting Mr. Spencer's doctrine, wherein does it help the theory of Conservation of Energy? When forces are correlated into thoughts and volitions, what then? How is any further change to be gotten out of them, any other mode of force to be extracted from them? Can a thought act on matter, take hold of it, and whirl it into motion? Can a thought make a top spin, or violin string vibrate? Clearly not, because the mind cannot grasp the conception of a thought, a mere particle of knowledge, going out, entering into, and driving matter through space. Therefore, if force can metamorphose into mental products, it is to be forever lost as force. But how is this answered? By giving to thought a kind of virtual power; by saying that thoughts inspire to deeds, and in that way, reinduce action; that is to say, that figuratively, or potentially, but not actually, thought is power or force. Now science has no use for figures of speech; and when ever any theory is forced to call upon them to bridge chasms, the sooner such theory is discarded the better. But were such a course of reasoning at all allowable, still there could be no quantitative relation between the force spent in thinking, and the product of thought, because there can be no ratio between the effort of thinking and the wrought out results of the thought.

But once more, the thought is itself impossible. It is possible to think of gold becoming bread, or milk, or meat, but not of its becoming time. So, it is impossible to think of motion becoming force, or force, motion, by a mind which has once accurately distinguished between the ideas. Equally so, it is impossible for such a mind to conceive of force, or motion either, for that matter, being converted into thought, will or feeling.

And now, I think, that it may well be replied to Mr. Spencer, that, "whoever duly weighs the evidence will see, that nothing but an overwhelmng bias in favor of a preconceived theory, can explain its acceptance," to wit, the correlation of physical forces with mental phenomena. But duly weighing the evidence is the difficulty, since the words and terms used to balance it in the scales of reason, are wrongly marked and numbered.

If thought, will, and feeling, are but metamorphosed physical forces, there is no use for mind, for there is nothing for mind to do. At most it becomes a bundle of cognitions. volitions, and emotions.

Prof. Bain, is a Conservationist but I do not understand him to push the theory to the extremity that Mr. Spencer does. He does not claim, as I understand him, that physical forces produce mind, or mind products, but only that there are invariable and parallel correspondences, between nervous and cerebral action on the one hand, and mental processes on the other; that every mental action is accompanied by a definite expenditure of brain force, but not measurable by our present appliances. This, as I have shown, may all very well be, without the necessity of thinking that such expended forces metamorphose either into mind, or mind products; for it is entirely logical to suppose, either that brain activities mark the occasions for mental action, or that the mind acting as a director of all the forces of the physical body, causes these cerebral actions in correspondence to, or as a means of, its own processes.

I think that I may say in conclusion that my arguments demonstrate that two of the grand forces of nature, perhaps the two primordial forms of force, and perhaps indeed the original and correlative form of all other forces, Gravitation and Molecular Cohesion, are constantly received forces by the material Cosmos from without, and that these forces as well as muscular force and all other forms of motive force are constantly under various circumstances and in various ways exhausted and dissipated. I think also that I have shown that in both plant and animal life there are principles of a higher order than any form of force, and which are not transformations or correlations of force, and indeed for which no correlations can be found in physics.

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